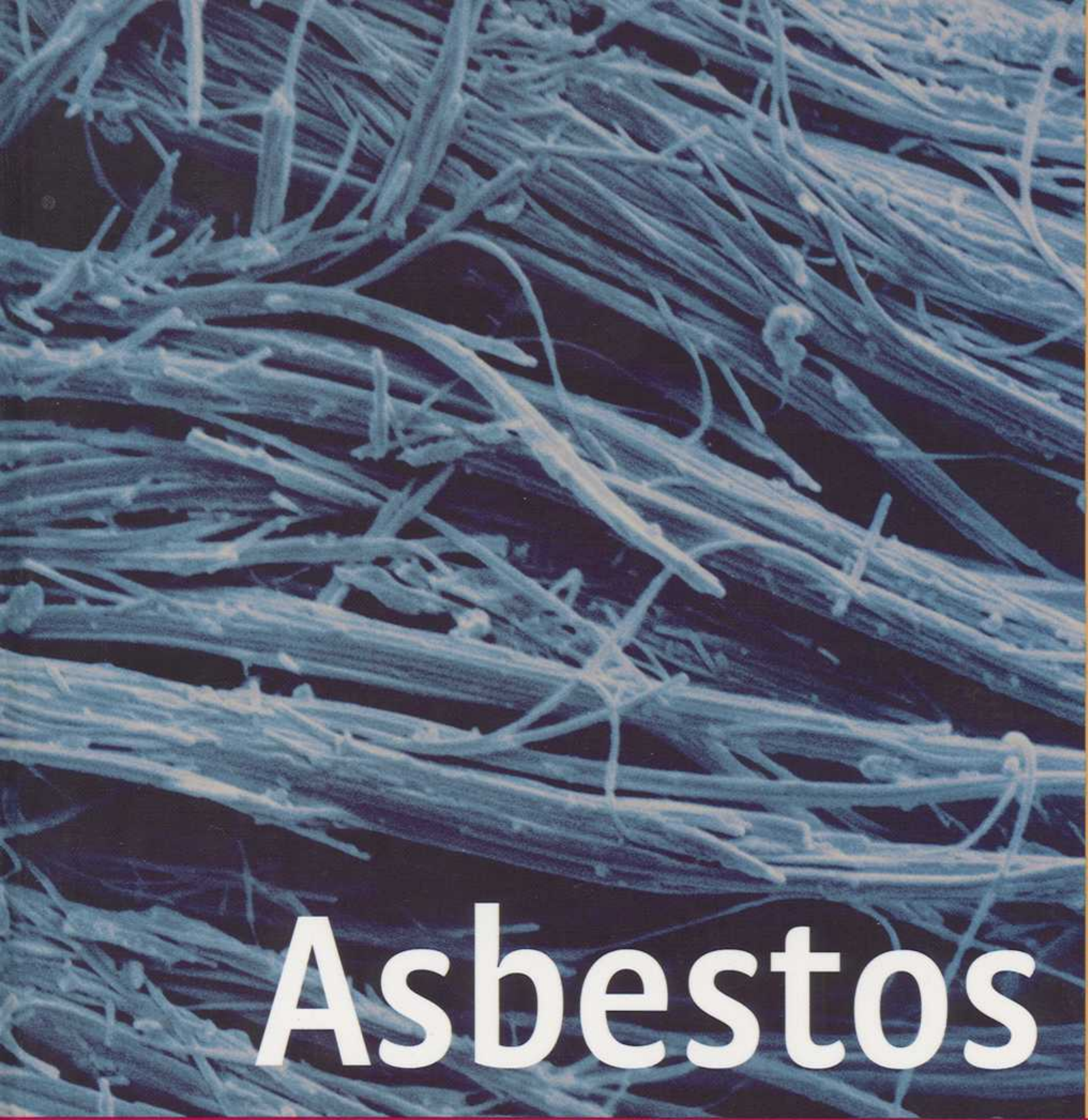

Second Edition

Asbestos Control:

Surveys, Removal, and Management

Andrew F. Oberta

ASTM INTERNATIONAL
Standards Worldwide

Asbestos Control: Surveys, Removal, and Management—Second Edition

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Foreword

THIS PUBLICATION, *Asbestos Control: Surveys, Removal, and Management-Second Edition*, was sponsored by ASTM Committee E06 on Performance of Buildings. The author is Andrew F. Oberta, The Environmental Consultancy, Austin, TX. This is the second edition of Manual 23 in ASTM's manual series.

Contents

Preface to the Second Edition

THE FIRST EDITION OF this book, titled *"Manual on Asbestos Control—Removal, Management and the Visual Inspection Process"* was published in November 1995 and as the title indicates, the emphasis was on the use of ASTM Standard Practice for Visual Inspection of Asbestos Abatement Projects (E 1368). The book reflected asbestos regulations then in effect and current practices and problems in the asbestos control industry. It contained examples and illustrations from my own then-recent experiences.

That was then and this is now. While the first edition of the *Manual* was in preparation the U.S. Environmental Protection Agency (EPA) revised the Model Accreditation Plan [1] and the Occupational Safety and Health Administration (OSHA) issued completely new asbestos regulations for the construction industry and for general industry [2]. EPA revised the Asbestos Worker Protection Rule [3] that brings government agency employees in certain states under the OSHA asbestos regulations. However, the EPA AHERA regulations have not been updated since they were published in 1987 [4], nor has the NESHAP been revised since 1990 [5]. Since that time, various states have issued or revised their own asbestos regulations. Although these efforts are too numerous to document, they are extremely important nonetheless. Over 30 countries throughout the world have existing or pending bans on the use of asbestos [6]; unfortunately, no such a ban exists yet in the United States.

The preface to the first edition noted that the asbestos control industry of the early 1990s had "matured" in the sense that techniques had become fairly standardized, a regulatory framework was in place and the revolving door of contractors, consultants, training providers and laboratories had slowed down. That remains the situation ten years later. Building owners are, for the most part, knowledgeable about asbestos control, they know their budgetary limitations, and they have established relationships with the suppliers of services on whom they depend to do the work. The technology of asbestos control has stabilized as well. Air and bulk sample analysis by Transmission Electron Microscopy (TEM) is now routine and affordable, as is dust sampling and analysis. But asbestos-containing material (ACM) is still removed the same way it has been for over 20 years in a labor-intensive process with strict controls on fiber release and contamination.

ASTM International has remained active in the development of standards for the asbestos control field. Task Group E06.24.03 on Asbestos Management remains responsible for ASTM E 1368, which has been revised seven times since its original publication in 1990. ASTM Standard Practice for Comprehensive Building Asbestos Surveys (E 2356) and ASTM Standard Practice for Maintenance, Renovation and Repair of Installed Asbestos Cement Products (E 2394) have recently been published and are discussed in this edition of the *Manual*. Subcommittee D22.07 on Asbestos Sampling and Analysis has published three test methods for settled dust: D 5755 [7] and D 5756 [8] on the microvacuum method and D 6480 on wipe sampling [9].

These ASTM standards represent the efforts of many people over the past 25 years, not only the ASTM members and others who participated in the development of the standards but also those in the greater community of the asbestos control field whose activities influenced the standards. This collective experience thus provides the technical foundation for this *Manual*, whose primary purpose is to facilitate the use of the standards.

Although this *Manual* draws on this broad foundation embodied in the standards, the examples and illustrations herein are almost entirely from my own experience. This book is not the result of a literature search, nor is it a collection of anecdotes from my colleagues. Consequently, any errors or inaccuracies are my responsibility and mine alone.

I would like to express my gratitude to the people who participated in the original development of ASTM E 1368 and to its subsequent revisions as well as to those, in particular, Bill Cavness and Tod Dawson—who contributed to the development of ASTM E 2356. Appreciation is also due to Alan Winterfeldt, Chairman of Subcommittee E06.24, for his continued support, and to Steve Mawn, ASTM Staff Manager for Committee E06 on Performance of Buildings. Finally, I would like to recognize my co-instructors in the *Standards for Asbestos Control* courses: Mike Beard, Steve Hays, Bill Ewing and Jim Millette, as well as Scott Murphy, manager of the ASTM Technical and Professional Training, for his support.

I also wish to thank Mary McKnight, who chaired the Peer Review Committee, and those reviewers (who must remain anonymous by ASTM policy) who took their valuable time to read the draft of this revision and offer their detailed and insightful comments. Finally, I wish to thank Kathy Dernoga and the other ASTM staff members for all of their hard work for this publication to come to fruition.

Probably the most gratifying comment about the first edition of the *Manual* came from a lawyer, of all people. She told me that, in addition to learning a lot about the subject, she enjoyed reading the book. If you have the same reaction to this edition, then my efforts have been rewarded.

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Austin, Texas

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[6] *Asbestos Strategies: Lessons Learned about Management and Use of Asbestos,* Global Environment & Technology Foundation, Annandale, VA, May 16, 2003.

[7] D 5755 Standard Test Method for Microvacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Structure Number Surface Loading.

[8] D 5756 Standard Test Method for Microvacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Mass Surface Loading.

[9] D 6480 Standard Test Method for Wipe Sampling of Surfaces, Indirect Preparation, and Analysis for Asbestos Structure Number Concentration by Transmission Electron Microscopy.

1 Holistic Approach to Asbestos Control

THIS *MANUAL* DISCUSSES THE THREE PRINCIPAL elements of an asbestos management program: building surveys, abatement projects and Operations and Maintenance (O&M) programs in the context of ASTM standards that cover these activities. Figure 1 shows how they are related and serves as a guide to using this *Manual*.

Because asbestos-containing materials (ACM) can't be managed without knowing where they are, an asbestos management program rests on a foundation of information provided by the Baseline Survey. Chapter 2, therefore, introduces the ASTM E 2356 Standard Practice on Comprehensive Building Asbestos Surveys with a discussion of Baseline Surveys for long-term management in place. Part of the Baseline Survey is an assessment of the ACM to decide whether to remove ACM or leave it in place and continue to manage it. Chapter 3 is devoted to the assessment process and introduces a graphical technique that helps in making this decision.

For situations where the assessment leads to a decision to remove the ACM, we return to Chapter 2 and ASTM E 2356 for a discussion of the Project Design Survey that provides information for designing an abatement project. Because many projects are done for renovation and demolition, Fig. 1 shows these as alternates to assessments as reasons for abatement, which still must be preceded by a Project Design Survey.

Chapter 4 on abatement goes through a project using ASTM E 1368 Standard Practice for Visual Inspection of Asbestos Abatement Projects in a way that maximizes the chances for success of the project. It covers the *visual inspection process* from project design through site preparation, removal and clean up, and air sampling for final clearance. The visual inspections called for in ASTM E 1368 are described in detail.

Chapter 5 goes beyond the basic ceiling scrape that most people envision when they think of asbestos abatement. Still focusing on ASTM E 1368, it covers floor tile removal and a few other techniques used in special circumstances. Two other ASTM standards, Test Method for Cohesion/Adhesion of Sprayed Fire-Resistive Materials Applied to Structural Members (E 736) and Practice for Encapsulants for Spray- or Trowel-Applied Friable Asbestos-Containing Building Materials (E 1494), are introduced in the discussion of encapsulation.

Because it is neither necessary nor possible to remove all of the ACM in a building at once, Chapter 6 helps you learn how to live with it. The first part of this chapter applies the concepts and methods of ASTM E 1368 to an O&M program. The second part is devoted to using Negative Exposure Assessments to gain relief from some of the provisions of the OSHA asbestos standards while still remaining in compliance with them. The last part briefly introduces ASTM Standard Practice for Maintenance, Renovation and Repair of Installed Asbestos Cement Products (E 2394), published just before this *Manual* went to press.

Chapter 7 (not shown in Fig. 1) covers some issues on respiratory protection and safety because they affect building surveys, abatement projects and O&M work. Throughout the chapters, the information follows the sequence of activities that are discussed in the ASTM standards while sidebars cover issues related to these activities.

This *Manual* is quite thorough in its treatment of the subject matter, but it is not a complete discussion of the hazards of asbestos and means of controlling them. It is not a text for "Asbestos 101" nor does it attempt to take the place of training manuals for asbestos courses required for accreditation and licensing. Some topics ordinarily found in such manuals are not covered at all—health effects, for example, as the reader is presumed to be aware of the well-known hazards of breathing asbestos fibers. Other topics, such as laboratory techniques, respiratory protection, engineering controls and safety are discussed in the appropriate context, but without discussion of fundamentals that might be covered in training courses.

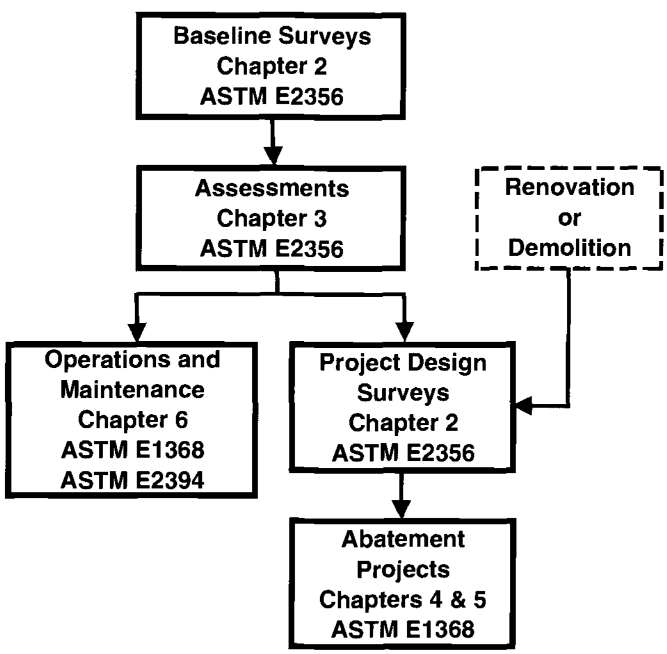

Fig. 1—Asbestos management activities and ASTM standards as covered in this *Manual*.

2

Comprehensive Building Asbestos Surveys

THE FIRST STEP IN MANAGING ASBESTOS-containing materials (ACM) is finding out if there are any to be managed, and if so, getting the information to do it properly. This activity is called an inspection in the AHERA regulations, and the individuals who do it are accredited inspectors. To avoid confusion with visual inspection (more on this in Chapter 4), we will use the term *building asbestos survey*, defined as follows in ASTM Standard Practice for Comprehensive Building Asbestos Surveys (E 2356):

> ". . . an activity to determine the presence, location, condition and quantity of asbestos-containing materials in a building or facility, or on the property containing the building or facility."

Throughout this *Manual*, the phrase "building or facility" will frequently be used, as not all ACM is within a structure identifiable as a building and many facilities consist of more than one building. ASTM E 2356 and this chapter describe two types of surveys—Baseline Surveys and Project Design Surveys. The word Comprehensive is significant, as it distinguishes these surveys from a similar activity that is much more restricted in scope and purpose—the Limited Asbestos Screen.[1]

The purpose of the Comprehensive Building Asbestos Survey is to locate, identify, quantify and assess ACM for ongoing management, including Operations & Maintenance and abatement. The standard is "comprehensive" because it tells how to get the information needed to manage ACM, whether it is left in place or taken out. Assessment of ACM is the part of a survey that Appendix X2 of ASTM E 2356 covers and Chapter 3 of this *Manual* explains in detail.

Qualifications

Regardless of the type of survey, the people who will be involved with the effort need accreditation in one or more of the following disciplines under the EPA Model Accreditation Plan (MAP). Each discipline brings a different set of skills to the task of conducting the survey.

- Inspector—required to take bulk samples, assess the condition of ACM and prepare the report;
- Management Planner—required for schools, and a desirable credential for all buildings and facilities, for assessing the potential hazards of ACM and developing a plan of action for their remediation;
- Project Designer—desirable for a Project Design survey that will provide information for abatement plans and specifications, which must be prepared by an accredited project designer;
- Contractor/Supervisor—again for a Project Design survey, this would be helpful for the knowledge of abatement processes.

A sometimes-overlooked nuance of AHERA is that accreditation of a *laboratory* under the National Voluntary Laboratory Accreditation Program (NVLAP) to *analyze* bulk samples does not constitute accreditation for anyone to go into the building and take the samples—the *individual* who takes the samples must be accredited as an *inspector*.

The owner or manager of the building or facility, who contracts for the survey, or a staff member overseeing the work, should have at least a two-hour Asbestos Awareness course.

Baseline Surveys

The Baseline Survey addresses the long-term aspects of asbestos management, while the Project Design Survey provides the information needed to design and conduct an abatement project. They have similar methodologies, but there are significant differences between the two.

A Baseline Survey consists of more than the collection and analysis of samples, and the report is more than a compilation of laboratory results. Taking a few bulk samples in an emergency, for example, does not constitute a survey as defined in ASTM E 2356. This type of survey has often been called an "AHERA survey" because the requirements in the EPA asbestos regulations for schools became a *de facto* standard of care in the industry. That development has resulted in some consistency in matters such as the training and accreditation of inspectors, the number of samples taken, how samples are analyzed, and how the condition of asbestos-containing materials is assessed. Unfortunately, it has also resulted in a mindset that limits how surveys are performed in situations where the restrictions of AHERA should not apply.

AHERA was designed for schools, and many buildings and facilities don't even remotely resemble schools. For instance, a lot of the ACM in a refinery (Fig. 2) or power plant (Fig. 3) is out of doors. Except for a few specific items, AHERA regulations don't require sampling of suspect materials outside the building. AHERA regulations don't require assessing the condition of non-friable materials, even if samples are taken. Doesn't a building owner care about the crumbling Transite panels on the cooling tower or the well-scuffed vinyl asbestos tile in the offices? The Baseline Survey described in ASTM E 2356 does not include these limitations that are part of the AHERA regulations.

[1] This term is used to describe an inspection of a property, often in conjunction with an environmental site assessment, done to facilitate a financial transaction.

Fig. 2—A lot of the ACM in a refinery is outdoors.

Fig. 3—The same is true for a power plant.

The OSHA asbestos standards do not explicitly require that a building or facility be inspected for ACM, a point that the agency stressed when the standards were first announced. The regulations merely require employers to notify their own employees and "employers of other employees" of the "presence, location and quantity of ACM and PACM." This amounts to a *de facto* mandate to inspect a building or facility if anything is going to be done that remotely affects the ACM—even managing it in place. What is PACM? It is OSHA's way of describing materials that AHERA lets one "assume" to contain asbestos, but PACM is more narrowly defined:

> "Presumed Asbestos Containing Material means thermal system insulation and surfacing material found in buildings constructed no later than 1980. The designation of a material as "PACM" may be rebutted pursuant to paragraph (k)(5) of this section."

The "rebuttal" of PACM requires an inspection done according to the AHERA regulations, or at least ". . . analysis of bulk samples collected in the manner described in 40 CFR 763.86."[2] A Baseline Survey, at least as far as surfacing material and thermal system insulation are concerned, therefore constitutes a "rebuttal of PACM" and must conform to the OSHA requirements. Resilient flooring materials installed no later than 1980 are not defined as PACM but are treated the same way in the regulations.

Many surveys are conducted by a consultant who holds the proper credentials, or a consulting firm that employs such individuals, under contract to the owner of the building or facility. ASTM E 2356 describes the following major activities for a Baseline Survey conducted under such an arrangement. The same process applies to surveys conducted with the owner's staff.

Planning the Survey

Planning for the consultant starts with a review of the owner's requirements and preparation of a proposal in response thereto. Many surveys rapidly get off on the wrong foot when the building owner fails to clearly state his requirements, or the consultant fails to understand what the owner needs or wants (which can be two different things). Cost is definitely an issue here, and some consultants promise more than they can deliver for the price the owner is willing to pay. Worse, the consultant is deluded into losing money on the survey in the hope of getting well on a resulting abatement project—work that may never materialize. Consequently, the quality of the survey suffers, the owner is disappointed and the consultant's liability risk goes up.

ASTM E 2356 contains a detailed explanation of the following cost items as a guide to preparing a realistic proposal for a Baseline Survey. Although it does not provide numerical data, this section explains the factors and decisions that affect all of these costs.

- Preliminary site visit
- Document review
- Preparation and mobilization
- Travel time and subsistence
- Survey personnel
- Sample collection and processing
- Quantifying and assessing ACM
- Data review and interpretation
- Report preparation
- Laboratory fees

The scope of the survey is first defined in terms of the physical areas to be inspected. For a multi-building facility, determine which buildings are to be included and if there are any structures or equipment outside of the buildings. In a multi-story building, find out which floors are to be inspected. For a large or complex building or facility, a preliminary site visit might be advisable.

There are many reasons that areas of a building or facility are excluded from a Baseline Survey, and some of these are discussed in **Excluded Locations—Some Examples.** Sidebar 1. Regardless of the reason for not inspecting a building or part of a facility, make sure to document the fact in your proposal and, later, in the survey report.

Obtaining and Reviewing Information

Review any information on the building or facility that the owner can readily provide, including reports on previous surveys if any were performed. There are practical limits to

[2] As originally published, 29CFR1926.1101(k)(5) required three samples of each homogeneous area. This requirement was soon deleted and replaced with the reference to the cited section of the AHERA regulations.

Sidebar 1—Excluded Locations—Some Examples

There are a number of reasons why some functional spaces are not inspected during a Baseline Survey.

- Concealed spaces where the fabric of the building—walls, ceilings, chases, etc. must be breached for access (Fig. 4). This "destructive testing" is expressly excluded from the scope of a Baseline Survey in ASTM E 2356.
- Physical access limitations may exclude areas that are inordinately difficult to enter. Safety considerations might exclude attics without flooring where the ceiling may not bear your weight, elevated locations where fall protection is required, or any area that might meet the definition of a confined space. No one expects you to risk life and limb to collect a bulk sample.

Particularly in industrial facilities and power plants, there will be thermal system insulation that is simply inaccessible without using a man-lift, as in shown in Fig. 5. Unless such equipment is provided the prudent approach is to limit bulk sampling and close-up inspection to pipes and other components that can be reached from ground level when standing on an 8-ft (2.4 m) stepladder, a permanently-mounted access ladder (Fig. 54, Chapter 3) or a permanent catwalk, as on the left in Fig. 5.

ACM that is not physically accessible should be reported as PACM, including pipe insulation inside metal jacketing. By visually observing it from the closest safe vantage point, it can still be assessed according to the protocols in Chapter 3.

- Institutional access limitations exclude places where the building owner doesn't want you to go, or where access will be tightly controlled. Security is an obvious reason. Don't be surprised at being told that a floor of a Federal Building is off limits because the FBI occupies the space. When inspecting a U.S. District Courthouse, we were told to stay out of the basement because people in the Witness Protection Program were housed there. In a postal facility, the "lookout galleries" used by Postal Inspectors may not be accessible for the survey (Fig. 6).

Sometimes relations between the building owner and a tenant over asbestos or another issue are sufficiently sensitive that you will be instructed to exclude that space from the survey. Hospitals are particularly sensitive installations because of privacy considerations as well as the obvious restrictions related to medical treatment, and the places you can go and the times you can go there without disturbing patients and staff may be severely limited.

I have inspected correctional facilities under the unrelenting watch of armed guards. While surveillance of this intensity is unusual, do not be surprised if a representative of the building owner insists on being present during the inspection, and do not hesitate to raise the issue while planning the survey.

- Roofing materials are often excluded because penetrating the membrane or flashing to take a bulk sample can void the warranty. The scope of work should make it clear as to who patches the holes if roofing materials are sampled. ◆

Fig. 4—Exposed pipes at ceiling and risers concealed in chase.

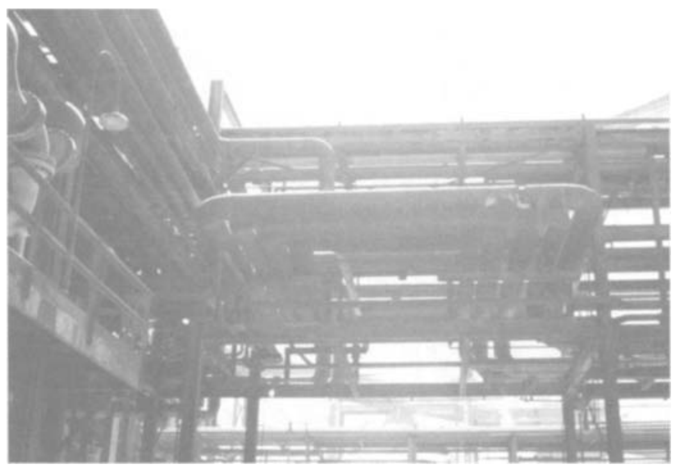

Fig. 5—Some thermal system insulation may not be safely accessible.

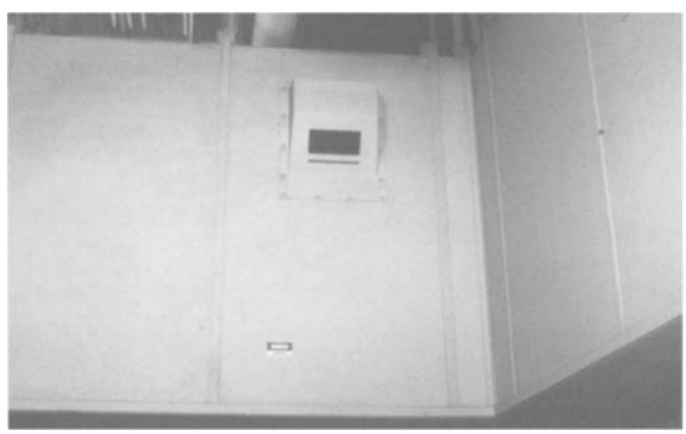

Fig. 6—Lookout gallery in postal facility.

this approach, one being the ability and willingness of the owner to search his files and the possibility that it would be a waste of time to do so. It helps to have floor plans and drawings of building systems, provided that they are current and clear enough to help plan and document the survey. "As-built" drawings rarely stay that way for long, and don't be surprised to be handed drawings so old they are barely legible. How much help a previous survey report will be depends on when and how well it was done. Don't expect a survey done in the early 1980s to mention the floor tile. ASTM E 2356 recommends believing the results of positive samples but re-sampling any materials where negative results may be in doubt, particularly those reported as "trace" quantities of asbestos. "The decision," says ASTM E 2356, "should take into account whether a sufficient number of samples were previously taken and if analytical methods were adequate."

As discussed later in this chapter, one material that merits re-sampling is floor tile if the previous results by PLM were negative.

Conducting Fieldwork

The fieldwork starts with mobilizing the people, equipment and supplies to do the survey. The people will have the aforementioned qualifications and someone in charge with the appropriate degree of experience and leadership skills. Organization of the fieldwork before leaving the office is important.

Conducting a Baseline Survey requires an understanding of two definitions that trace their roots to the AHERA regulations: functional spaces and homogeneous areas. These are illustrated in Fig. 7 and defined as follows:

Functional space—an area within a building or facility that is used for a specific purpose.

Homogeneous area—surfacing material, thermal system insulation material, or miscellaneous material that is uniform in color and texture, and apparent or known date of installation.

Figure 7 shows seven functional spaces—mechanical penthouse, conference room, offices, shipping, manufacturing, basement and crawl space and nine homogeneous areas—roofing, duct insulation, lay-in ceiling tiles, plaster ceiling, fireproofing, floor tile, tank insulation, and hot and cold water pipe insulation.

It should be no surprise to find some functional spaces with more than one homogeneous area—floor tile and fireproofing in an office, for example. Obviously, that floor tile can extend over more than one functional space—such as from the office out into the hallway. At the start of the survey, decide if the basic unit of organization for the work is going to be functional spaces or homogeneous areas. Because the building is divided by its walls and floors into functional spaces and the survey requires entering most or all of them, it is more logical to plan, conduct and document the survey on that basis. Document each functional space entered and the suspect materials found therein that are representative of the homogeneous areas, whether a sample is taken or not. If there are no suspect materials in a functional space, document that fact. Going through the building room-by-room is usually easier than finding a pipe or beam with suspect material and tracing it around the building, but some may prefer to do this and use the homogeneous area as the basic unit of organization. If the scope of the survey is limited to mechanical systems, it might be preferable to start in the mechanical room(s) and follow the pipes through the building. For a building served by a central steam plant, find out where the steam lines enter the building and start there.

Fieldwork consists of collecting samples and information. The three-day training course for inspectors described in the MAP covers which materials to sample, where to take the samples and how many samples to take. Unlike AHERA and the MAP, ASTM E 2356 does not distinguish between ACM and ACBM—asbestos-containing *building* materials. See ***When Is ACM Not ACBM?*** Sidebar 2. for some ACM that is sampled under ASTM E 2356 that would be excluded under AHERA because it is not ACBM.

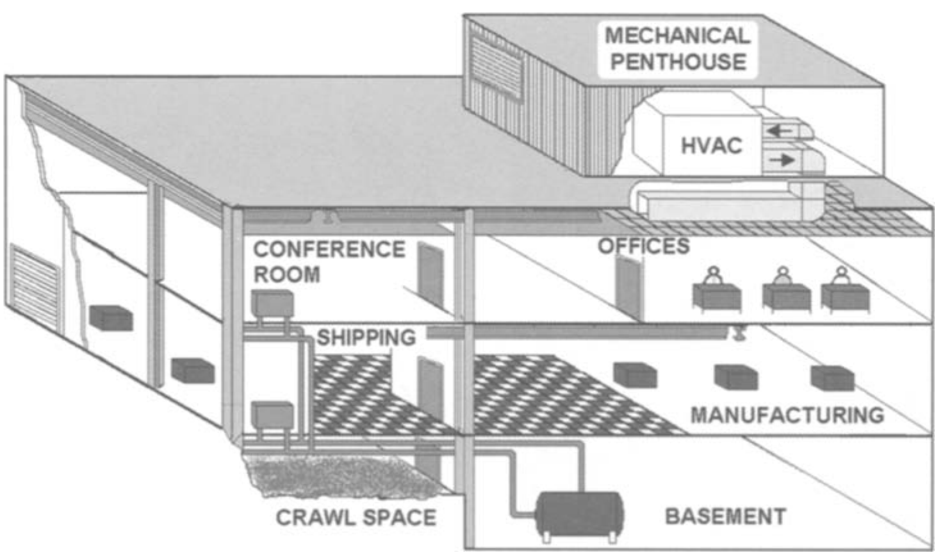

Fig. 7—Functional spaces and homogeneous areas in a typical building.

Sidebar 2—When Is ACM Not ACBM?

The emphasis in the AHERA regulations is on inspection for ACBM—asbestos-containing *building* materials—defined therein as: ". . . . found in or on interior structural members or other parts of a school building." There is a six-paragraph definition of *school building* that includes "Any portico or covered exterior hallway or walkway" and "Any exterior portion of a mechanical system used to condition interior space." Which locations are inside or outside the building and what gets sampled and doesn't remain subjects of confusion and endless debate in training classes.

A Baseline Survey done according to ASTM E 2356 avoids these limitations and resulting confusion by requiring all materials inside and outside the building to be sampled, including:

- Materials on the premises that have *not* been installed. Examples include gaskets (Fig. 8), packing and sealants in storage for use in maintenance and repair. There may even be a box of asbestos-containing floor tile (Fig. 9). All of these loose materials should be sampled if they are not identified as asbestos containing or "asbestos-free" on the package or in a Material Safety Data sheet. The building owner may decide to dispose of them as asbestos containing, which may cost less than the sampling, analysis and documentation of the results.
- Systems that are not associated with a particular building but are clearly part of the facility. Steam, condensate and water lines may traverse large distances between a central boiler plant and the buildings they connect. These lines may be above ground (Fig. 10) or buried. Exposed and buried electrical ducts are another example, as are buried asbestos-cement pipes in water and sewage systems.
- Equipment located in the building that may have its own external and internal insulation as well as gaskets and packing. Some of this equipment may be part of the building's operating systems, such as HVAC units. Other items may be associated with the function of the facility, such as turbines and boilers in a power plant (Figs. 11 and 12) or production equipment in a factory. Access to this equipment for inspection and sampling will be more difficult to arrange for than construction materials, as it would entail shutting the equipment down and maybe cooling it off, taking it out of productive service and disassembling it, followed by reversing this procedure to return it to use. An accredited inspector would probably not be qualified to disassemble the equipment to the extent needed to find and sample the suspect material, nor would he necessarily have the tools and equipment to do so. The best time to inspect these items is when they are taken out of service for routine maintenance or during a plant shutdown, which is unlikely to conveniently coincide with the time that the Baseline Survey is performed.◆

Fig. 8—Sheet of asbestos-containing gasket material.

Fig. 9—Nine-inch by nine-inch vinyl asbestos floor tile in original box.

Fig. 10—Steam and condensate lines suspended from utility poles.

Fig. 11—Removing a hatch from a turbine takes special tools and skills.

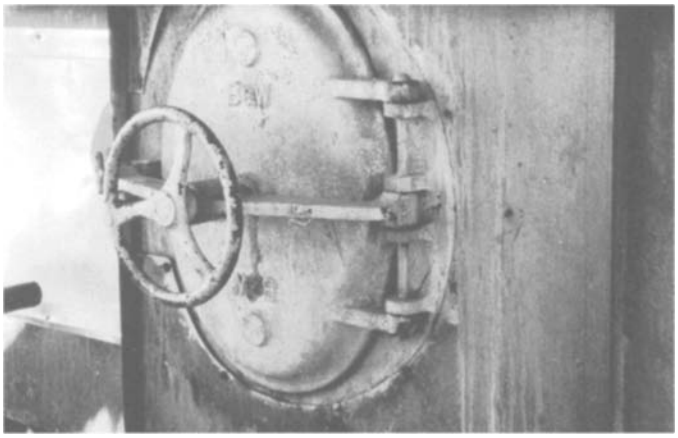

Fig. 12—Boiler doors should be opened by a plant worker, not the inspector.

The "3-5-7 rule" specifies the number of bulk samples of surfacing material to be taken, depending on the size of the homogeneous area:

- For <1,000 ft^2 (93 m^2) take at least three samples
- Between 1,000 ft^2 and 5,000 ft^2 (465 m^2) take at least five samples
- Over 5,000 ft^2 take at least seven samples

What are the practical implications of this "rule?" Obviously, seven samples may not be enough to properly characterize a very large amount of surfacing material, such as the plaster ceiling of an auditorium. Also, some surfacing material is not easily quantified in ft^2 or m^2—fireproofing on beams, columns and other structural members being the perfect example. For structural steel, a good approximation of the surface area can be made by multiplying the perimeter of the cross-section (in feet or meters) by the length of each structural member and summing the results. The fact that a building contains structural members of varying lengths, shapes and sizes (Fig. 13) complicates this process, but the information will eventually be needed to quantify the fireproofing if it contains asbestos.

Where do you take the samples? The operative words are "representative" and "random." Samples are taken of suspect materials that are "representative" of the homogeneous area—similar in color, texture and appearance—and, if approximately known, date of installation. "Random" locations are selected to compensate for the fact that some ACM was batch-mixed on site and may vary in its asbestos content over the locations it was applied to. If the plasterer or plumber ran out of asbestos fiber, there may be some places on the ceiling or some pipe fittings where a sample would contain equal to or less than one percent asbestos, while a sample taken elsewhere would contain greater than one percent asbestos. Random sample locations are determined by using the method in the EPA "Pink Book" [1] or a variation thereof.

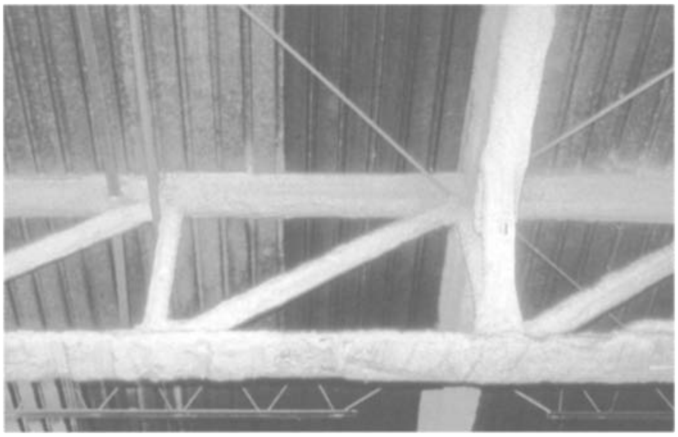

Fig. 13—Fireproofing on beams and joists can be difficult, but important, to quantify.

The random sampling scheme in the "Pink Book" works best on surfaces where a grid can be laid over the floor plan—ceilings and floors, for example. Each cell of the grid contains a number from 1 to 9, arranged at random, to indicate the sequence in which the samples are taken. Following the "3-5-7 rule" may result in skipping as many as six cells.

The random sampling approach has a lot of practical limitations. For one thing, if there is no reason to suspect inhomogeneity in the material, as in the case of ceiling tiles, floor tile or sheet vinyl flooring of uniform appearance, why bother with a random sampling scheme? The access restrictions we discussed will preclude getting a sample from some of the cells and it may be difficult to determine cell boundaries within the crowded confines of an office or other occupied space. The exact place to take the sample will be determined more by practical considerations, such as not disturbing occupants and your own safety, than by random numbers on a grid.

I used a linear application of random sampling once to determine where to take samples of steam and condensate lines suspended from utility poles on one of the bases that comprise Camp Lejeune, NC (see Fig. 10). My instructions were to inspect 78 pre-assigned locations to determine if the insulation was fiberglass or suspect ACM, then to take 30 samples of the suspect ACM. I used a random number table to decide where to take the samples from the locations with suspect ACM. A similar approach could be used for any facility with lots of pipe insulation, especially if there were a large number of fittings or indications of inhomogeneity in the insulation on the straight runs.

Appendix X1 of ASTM E 2356 includes detailed procedures for collecting bulk samples of 15 types of friable materials and 3 non-friable materials. There are some fundamental rules to follow when taking bulk samples:

- Bulk samples should always be taken after the material has been wetted with soapy water. The water will penetrate friable materials and spread over the surface of non-friable materials.[3] Don't over-do the wetting, however, or the laboratory will have to dry the sample before analyzing it, and that takes time.
- Choose a sampling tool appropriate for the material. Plugs can be extracted from thick materials like fireproofing and pipe insulation with a coring tool (Fig. 14). Thin materials like plaster and textured ceiling finishes are more easily scraped off. Brittle non-friable finishes like siding and floor tile can be scored and broken. Woven and matted materials such as HVAC vibration dampeners can be cut with scissors or a utility knife.

[3] "Amended water" is used for asbestos abatement to make sure the ACM is "adequately wet" before removal. Special formulations containing surfactants are sold by providers of abatement supplies. For taking bulk samples, adding a liquid detergent to the water works just as well.

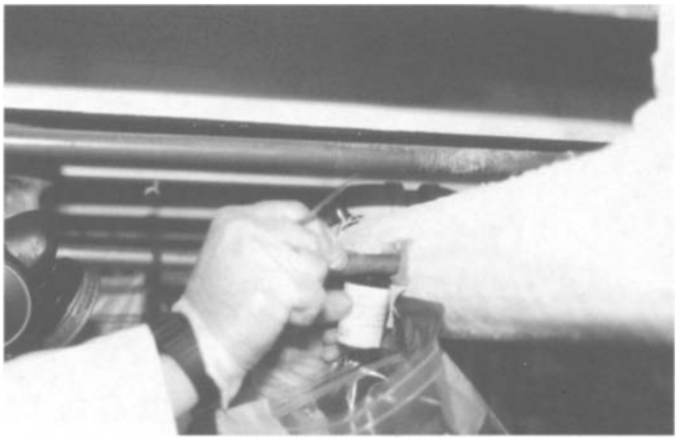

Fig. 14—Coring tool used to sample pipe insulation (note respirator on inspector).

- Follow the general rule of rigid containers for friable materials (use 35mm film canisters—glass vials break when dropped) and restrict the use of plastic bags to non-friables. A sample of fireproofing or pipe insulation may not be completely wet—fibers will escape if it is put in a plastic bag and the air squeezed out. For a vivid demonstration of this, try it with a sample known to be "asbestos-free" in a dark room, holding the bag in a flashlight beam.
- Take a large enough sample of floor tile to give the laboratory enough mastic on the back to analyze, particularly if specifying gravimetric methods (see *Analyzing the bulk samples*). A piece of tile that will fit in a quart-size freezer bag will have enough mastic—if the mastic sticks to the tile. If not, scrape more mastic off the floor. If aesthetics matter, replace the lifted piece of tile with some closely matching non-asbestos tile.
- Cover penetrations in friable materials with an adhesive label with the sample number printed on it. Make sure it is easily visible—if the pipe or beam is up in the rafters, put the label on the bottom so it can be seen from the floor. Have a plan in mind to cover these labels after the samples are analyzed with the proper OSHA label if the material contains greater than one percent asbestos (see 29CFR1926.1101(k)(8)) or, if not, an "ASBESTOS-FREE" label.
- Sample layered materials such as wallboard joint compound carefully to maintain the integrity of the layers. The laboratory is supposed to analyze the layers separately and report what is in each layer.
- To avoid contaminating a sample with residue from a previous sample, which may contain asbestos fibers, reusable sampling tools must be cleaned after each sample is taken. Coring tubes can be purchased or made that are used to extract a plug of material, then sent to the laboratory with the plug inside the tube. This helps to maintain the integrity of layers if present.

Before discussing what happens to the bulk samples, let's recall two statements from earlier in this chapter:

> "A Baseline Survey consists of more than the collection and analysis of samples, and the report is more than a compilation of laboratory results."

and

> "Field work consists of collecting samples and information."

In other words, some of the information from the survey will not be related to bulk samples but is needed to fully document the results of the survey. This information includes reasons why samples were not taken in some of the functional spaces inspected.

An accredited inspector is allowed to identify specific types of *thermal system insulation*—fiberglass, foam glass, rubber, or other non-ACBM—as non-asbestos without bulk sampling according to §763.86 of the AHERA regulations. This section is also invoked by the OSHA standards for rebuttal of PACM in situations where that definition applies.[4] The phrase ". . . or other non-ACBM" leaves a lot to the inspector's judgment—cork, for instance. Orange and yellow fiberglass insulation found on pipes and HVAC ducts will be the most common example. However, don't use this exemption as an excuse to avoid sampling the thin "skim coat" on fiberglass insulation (Fig. 15) or the mastic on HVAC ducts (Fig. 16).

What about yellow or pink fiberglass insulation batts? Rather than debate whether they are thermal system insulation because their purpose is controlling heat transfer between two spaces, which would make the exemption in §763.86 apply, just use a little common sense. Asbestos fibers were not used in the manufacture of these products. The

Fig. 15—Asbestos skim coat over fiberglass insulation.

[4] Remember that anyone can assume or presume that a material contains asbestos, but only accredited inspectors can conclude the opposite. Any other experience working with insulated mechanical equipment doesn't count.

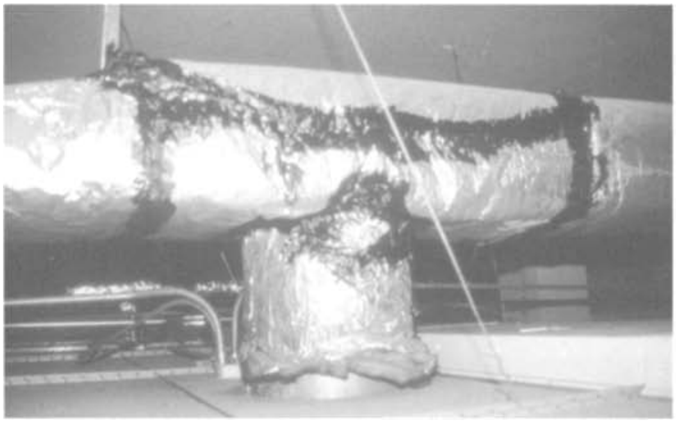

Fig. 16—Asbestos-containing mastic on HVAC duct insulation.

Fig. 17—Uninsulated condensate return lines on bottom of a unit heater.

same is true for obvious non-asbestos materials such as cement (including masonry blocks), porcelain fixtures, glass, wood and Masonite—this list is obviously not exhaustive. The important lesson is to document the fact that these materials were found, describe them sufficiently and report that no samples were taken. Of course, if there is *any* reason to believe that a material *might* contain asbestos—take samples.

Sometimes there is no suspect material present in the functional spaces—no insulation on the pipes, for example. It is common to see insulation on the steam lines but not on the condensate return, as in Fig. 17. Document the presence of uninsulated pipes or ducts, or structural steel and decks with no fireproofing. If there are no components in a functional space that could have ACM associated with them, at least record the fact that you entered the functional space and looked.

A logistical decision must be made whether to conduct the assessments (see Chapter 3) on the same site visit as when samples are collected. If extensive travel is involved, it may be more cost-efficient to assess all suspect materials at this time, before the results of the analyses are known. Some of the suspect materials assessed at this point will not contain asbestos and will have to be excluded from the tabulation of ACM in the report after the results are known. When inspecting your own facility or one close to your office, it might be more cost-efficient to dispense with assessment on the initial visit and go back to the site after reviewing the laboratory report. You can then limit the assessment to confirmed ACM, and use the follow-up visit to verify previously collected information and take additional bulk samples, if necessary.

Analyzing the Bulk Samples

The bulk samples will be sent to an accredited laboratory for analysis.[5] How should the samples be "processed," what information does the laboratory need, and what should they provide in the way of results?

The first step is referred to in ASTM E 2356 as "sample processing." If the field notes contain adequate information on the samples, they can go directly to the laboratory in their containers as they were originally collected. In this case the only "processing" needed is secure packaging and completing a Chain of Custody form. There are times, however, when conditions in the field—such as poor lighting—make it difficult to examine the samples and adequately record their color, homogeneity and other properties. A HEPA-filtered exhaust and an inexpensive stereomicroscope are a good investment, allowing examination of samples before sending them to an outside laboratory. This is also a good way to split samples for quality control purposes[6] and to archive part of a sample of particular interest.

Analytical Methodology

Figure 18 illustrates the approach to bulk sample analysis described in ASTM E 2356. The first step is analysis by PLM to identify the fibers, followed by visual estimation of asbestos content. If visual estimation shows the content to be greater than one percent asbestos, the material is reported as asbestos-containing. This is true whether or not the sample is identified as non-friable organically bound (NOB), defined in ASTM E 2356 as:

> ". . . materials that are not friable and that consist of fibers and other particulate matter embedded in a solid matrix of asphaltic, vinyl or other organic substances."

- For samples that are *not* NOB, if no asbestos fibers are identified on three replicate slide mounts the result may be reported as "No Asbestos Detected" (NAD) and no further analysis is required [2]. If asbestos fibers are identified but visual estimation shows the content to be equal to or less than one percent, the result must be confirmed by one or more of the following techniques: point-counting, gravimetric reduction and/or Transmission Electron Microscopy (TEM). If one of these methods shows the asbestos content to be greater than one percent, the sample must be reported as ACM.
- Samples identified as NOB are treated differently for confirmation of negative (equal to or less than one per-

[5] The AHERA regulations require bulk samples taken in schools to be analyzed by laboratories participating in the National Voluntary Laboratory Accreditation Program (NVLAP), operated by the National Institute of Standards and Technology. OSHA also recognizes NVLAP and also accepts the "Round Robin for bulk samples administered by the American Industrial Hygiene Association (AIHA) or an equivalent nationally-recognized round robin testing program." Some states have their own accreditation programs, such as the New York Environmental Laboratory Approval Program (ELAP), while others recognize the NVLAP or AIHA program.

[6] An old proverb says: "A man with one watch knows what time it is. A man with two watches isn't quite sure." Before you spend money on splitting samples, decide how you'll interpret the results.

cent) PLM results, as shown in the flow chart. For NOB samples, PLM and visual estimation can show asbestos content greater than one percent, but the sample cannot be reported as "NAD" based on three replicate slide mounts. This is because the analyst might not be able to see the short fibers in some NOB materials or fibers that are obscured by interfering substances. The only way to confirm that no asbestos fibers are present, or that they amount to equal to or less than one percent if present, is by point-counting, gravimetric reduction and/or TEM. This further analysis, of course, may show that there is greater than one percent asbestos in the sample.

The analytical techniques shown in Fig. 18 are collectively known as the "EPA-600" method [3]. The 1993 edition supplanted the 1982 method, which unfortunately is still referenced in the NESHAP and AHERA regulations. Briefly,

- Visual estimation consists of comparing the sample to reference samples of known asbestos concentration percentages for the type of asbestos identified. This may be done with a low-powered (15×–30×) stereomicroscope or with a higher-powered (100×) Polarized Light Microscope.
- Point counting is a more precise technique where a reticle containing a random array of 25 points (a Chalkley Point Array) is superimposed on the field of view containing the sample. Each point that falls on an asbestos fiber or other "non-empty" area is counted until 400 total points have been counted. The percent of asbestos in the sample is the number of points falling on asbestos fibers divided by 400.
- Gravimetry consists of removing interfering substances with acid washing and/or ashing, with the sample weighed after each step to determine the percent of asbestos fiber remaining in comparison to the original sample weight.
- Transmission Electron Microscopy (TEM) is used to identify the asbestos fibers on the basis of their morphological and chemical characteristics.

The NESHAP regulations place the responsibility for determining the asbestos content of bulk samples on the building owner, who must treat the materials they came from as asbestos-containing in the absence of analytical proof to the contrary. The owner also has the option to forego the additional analyses beyond PLM and treat the material as asbestos-containing. ASTM E 2356 places the burden on the accredited inspector to advise the owner of the options and consequences, and to request the appropriate analyses from the laboratory.

While the record of some laboratories for finding asbestos in floor tile by PLM is quite good, the consequences of missing it can be dire—see ***PLM, Point-Counting and NOBs***. Sidebar 3.

Positive Stop

ASTM E 2356 discourages the use of the "positive stop" approach, which is based on the premise that if one sample from a homogeneous area contains asbestos, all material from that homogeneous area must be treated as asbestos containing and the remaining samples need not be analyzed. The AHERA regulations specifically permit this approach.

The obvious advantage is saving the cost of analyzing one or more samples. With the cost of PLM analysis being as low as it is, these savings are minuscule compared to the cost of the overall survey. You still need to document where the samples were taken and explain why they weren't analyzed. Consider also the impression on your employer or client, who has spent money to have the samples taken and gets no information about what is in them.

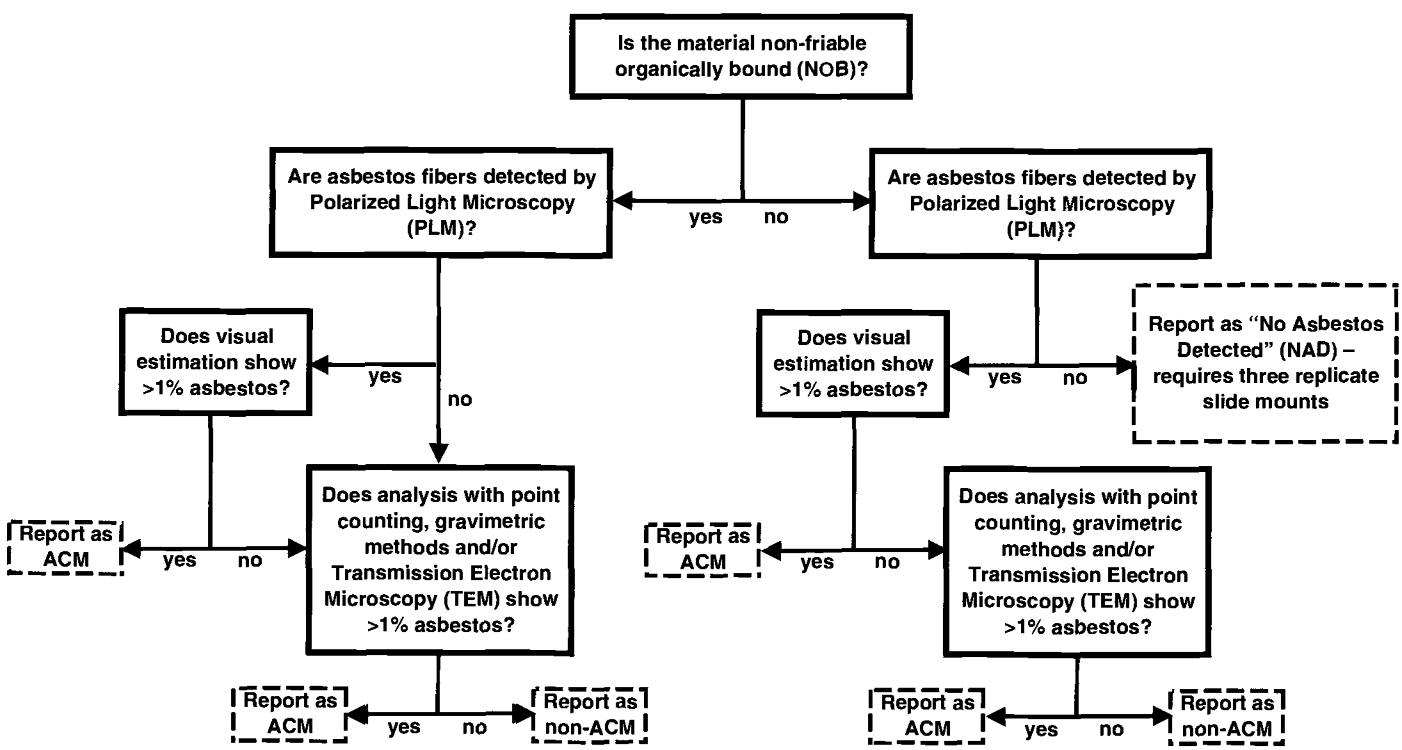

Fig. 18—Flow chart for bulk sample analyses.

Sidebar 3—PLM, Point-Counting and NOBs

Polarized Light Microscopy (PLM) is very good at finding asbestos fibers in friable materials and at high concentrations. It is not very accurate, but if the estimate is 40% chrysotile, who cares if it is off by 4%? If the estimate is 4%, it matters greatly—one laboratory gives the "acceptable variance" of its PLM results in the 4-6% range as +/– 4%. Some owners try to get samples with low asbestos content—but still above one percent—"point-counted into compliance" to show that the material isn't really regulated as ACM. This approach is fraught with danger, due to the inherent inaccuracy of the PLM method.

The problem with PLM analysis arises mostly with vinyl asbestos tile, where the fibers are small and obscured by the binders. Floor tile was apparently the sausage of the asbestos products industry, and mill scraps unsuitable for other purposes ended up in vinyl asbestos tile (VAT). Vinyl floor tile of the 9 in. × 9 in. (23 cm × 23 cm) size, such as that on top in Fig. 19, invariably contains asbestos, but the 12 in. × 12 in. (30 cm × 30 cm) size on the bottom frequently does as well. A prudent approach is to confirm negative PLM results for all floor tile with gravimetric methods including TEM. The protocol used by most laboratories is commonly referred to as the "Chatfield Method" [1].[1]

Asphalt-based roofing materials, mastics and flooring are other examples of non-friable organically bound materials (NOB). In New York, confirmation of negative (equal to or less than one percent asbestos) results is required for all bulk samples of NOBs. The regulations state:

> ". . . NOBs must be analyzed by one of the gravimetric matrix reduction methods, either the PLM method (ELAP Item 198.1) or the TEM method described herein. This TEM method is the only method that can be used to report true negative results from NOB samples to clients" [2].

Laboratories have taken to putting disclaimers on negative results of floor tile analysis by PLM, referring to the results as "inconclusive." The New York ELAP Method 198.1, in fact, requires the following disclaimer on such results:

> "Polarized Light Microscopy is not consistently reliable in detecting asbestos in floor coverings and similar non-friable organically bound materials. Quantitative transmission electron microscopy is currently the only method that can be used to determine if this material can be considered or treated as non-asbestos-containing" [3].

The price of gravimetric and TEM analysis of NOBs has fallen to where these methods are competitive with point counting, and they are more accurate. I have adopted a policy of confirming PLM negative results for NOBs with gravimetry or TEM. One floor tile sample result was reported as "None Detected" by PLM and "2.19%–2.68% chrysotile" by TEM – by the same lab! What if I had just requested PLM and relied on the "None Detected" result? I might find myself in the same situation as a consultant who sampled floor tile in 1990 and was told it was negative by PLM. Years later, the owner had the tile analyzed by TEM before renovating the building and found out that it contained asbestos. It cost the consultant many times what he had been paid for the original survey to settle the lawsuit [4].◆

[1] In a personal communication, Eric Chatfield warned me against using the method for materials where a high percentage of residue remains after ashing and acid-rinsing. The example he used was plaster substrates.

References

[1] Chatfield, E. J., Determination of asbestos in resilient floor tile. Chatfield Technical Consulting Limited—Standard Operating Procedure SOP 1988-02 Rev. 03. Mississauga, Ontario, 1991.

[2] State of New York Environmental Laboratory Approval Program (ELAP) Certification Manual, Item No. 198.4, Transmission Electron Microscopy Method for Identifying and Quantifying Asbestos in Non-Friable Organically Bound Bulk Samples, Environmental Laboratory Approval Program, Wadsworth Center, Albany, NY, March 1, 1997.

[3] State of New York Environmental Laboratory Approval Program (ELAP) Certification Manual, Item No. 198.1, Polarized Light Microscopy Method for Identifying and Quantifying Asbestos in Non-Friable Organically Bound Bulk Samples, Environmental Laboratory Approval Program, Wadsworth Center, Albany, NY, May 15, 2000.

[4] Beard, M. E.,"Building Owner Sues IH Consultant over PLM Floor Tile Analysis," in *Environmental Health and Safety Solutions*, Environmental Information Association, Chevy Chase, MD, November 1999.

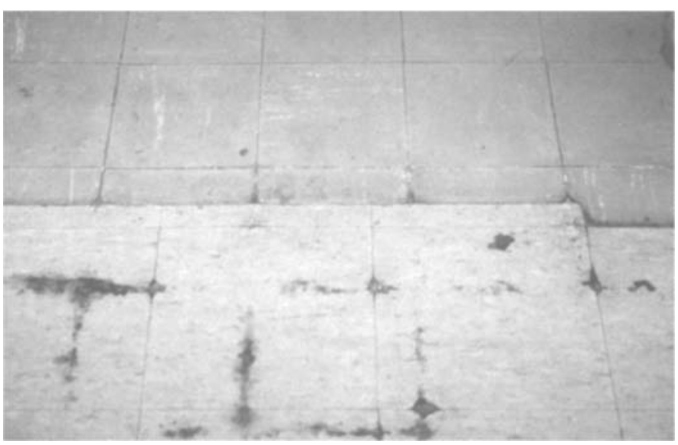

Fig. 19—Both common sizes of VAT contain asbestos.

The "positive stop" approach should only be used if absolutely sure of the homogeneity of the materials represented by the set of samples. In many cases the information obtained by analyzing all of the samples can more than justify the cost of doing so.

- Suppose, for example, seven samples were taken of acoustical plaster in a 5,000 ft^2 (465 m^2) area. The first one analyzed contains asbestos, so using "positive stop" would mean that the laboratory doesn't analyze the rest. At today's PLM rates, this would save about $60. Nothing is known about the asbestos content of the remaining six samples, some of which might not contain asbestos, indicating that they come from a different homogeneous area. Based on the result of one sample, the owner must now manage all of the plaster as ACM or spend on the order of $50,000 to remove it.
- Suppose the first three samples analyzed contain equal to or less than 1% asbestos and the fourth sample contains greater than one percent asbestos. The savings

from not analyzing the remaining three samples under "positive stop" is down to a paltry $30, and you are left wondering if the fourth sample represents a homogeneous area different from the one that the first three samples came from. Analyzing the remaining three samples could help to make that decision. This might create an incentive to revisit the site, take a closer look at the plaster, and maybe take more samples. A lot of the building owner's money is riding on the conclusions, and the stakes rise with the size of the homogeneous area.

Preparing a Report

It is worth repeating again: a survey report is not just a list of bulk samples and a collection of laboratory results. A survey report tells how the inspection was done, where ACM was found, what kind and how much. It includes recommendations and options based on a detailed assessment of the ACM, and a rough estimate of the cost of those options. ASTM E 2356 discusses the content of the Baseline Survey report and Appendix X3 contains a report template.

At a minimum, a Baseline Survey report should reference ASTM E 2356 and include:

- A description of the building or facility, its location and the responsible representative of the owner
- Building or facility characteristics, including basic dimensions, mechanical systems and construction materials
- Credentials of the inspector(s) and other accredited persons
- A description of the inspection, assessment and bulk sampling methodology
- A list of all functional spaces inspected and those excluded (with reasons)
- A list of all homogeneous areas sampled and those excluded (with reasons)
- Floor plans showing the locations of functional spaces inspected and homogeneous areas sampled and those excluded
- A list of bulk sample results with location, type of material, physical description and results of the analysis (asbestos content—type and percent—plus other major components)
- A tabulation of the assessments for all confirmed ACM (see Chapter 3)
- A tabulation of the quantities of all confirmed ACM
- Conclusions and recommendations for management of the ACM

The conclusions and recommendations section will reflect not only the bulk sampling results and quantities information, but also the qualitative or quantitative assessments of Current Condition and Potential for Disturbance conducted according to Appendix X2 of ASTM E 2356. What is the best way to phrase these conclusions and recommendations?

If no ACM is found, be careful how you report the findings. Statements such as "There is no ACM in the building" and "The building is asbestos-free" can come back to haunt you. Better to say: "No ACM was found in this building," which leaves open the possibility there may be some because you didn't look everywhere that ACM could possibly be located and didn't sample some materials for various reasons. Describe the limitations of the survey, and if any concealed spaces were not inspected or any suspect materials were not sampled, recommend that the owner have those spaces checked before they are entered (as for a renovation) and that any suspect materials found be sampled before they are disturbed.

If ACM was found, recommend that it be managed in place as long as possible and prioritize the removal of damaged and vulnerable ACM according to the assessments described in ASTM E 2356 (see Chapter 3). Remember that the purpose of a Baseline Survey is long-term management of ACM, which imposes a commitment on the building owner. It requires an O&M program, which is discussed in Chapter 6, which will cost money and affect peoples' work habits and attitudes. Unless the building owner—your client or employer—asks for help in implementing the O&M program, your influence on matters will soon come to an end. The best that can be done at this point is document the Baseline Survey methodology, results, conclusions and recommendations thoroughly and accurately in the report.

The cost of managing or removing ACM is what matters most to the building owner, and many survey reports contain an estimate of removal costs based on unit costs and quantities. Be aware that these costs are not a substitute for estimates based on a detailed project design. Building owners should critically review all survey reports, some of which unfortunately contain misleading information that can have serious consequences—see ***Survey Reports—Some Pitfalls.*** Sidebar 4.

Attachments should include copies of:

- Laboratory reports and credentials (NVLAP or other certificate)
- *Current* accreditation certificates for the inspector(s) and others
- Field data sheets for the inspection and sample collection
- Chain of custody forms for the bulk samples

Some further thoughts on the Baseline Survey report:

- Photographs of functional spaces and suspect ACM should be taken at a distance sufficient to identify the location of the ACM in the functional space. Not only are photographs useful to the reviewer, they can help the inspectors remember details when preparing the report without having to re-visit the facility.
- With the emphasis on security and confidentiality at many buildings and facilities, some owners may be reluctant to have site maps, floor plans or photographs included in the report. Doing so deprives the user of an important visual format for presentation of the information, but you might have to work within these restrictions. The owner may also impose limitations on retention and distribution of the information that is provided and generated during the survey.
- It can be helpful to show different types of ACM by color-coding and also to include color photos of the materials in relation to their surroundings. Because color in printed copies loses its value as soon as someone makes a copy on a non-color printer or copier or sends a fax, ASTM E 2356 requires that essential information be presented in black and white. For electronic submittals, the file size of large drawings and color photos can result in prohibitive transmittal times for those without access to high-speed lines. One must be careful to use a drawing format that is readily available—not every computer is equipped with AutoCAD.
- Electronic submittal of proposals and reports greatly expedites reviews, comments and other communications. The electronic files for all documents should be archived on a CD. A report submitted to a federal government agency in electronic format must comply

Sidebar 4—Survey Reports—Some Pitfalls

Years ago, one consulting firm was quite clever in the organization of their survey reports. The spread sheets of bulk samples and analytical results progressed across the pages to the quantities, which were multiplied by unit costs of removal. The products were summed and segued into a proposal from the firm, which was an integral part of the report, to design and manage an abatement project.

As is done for homogeneous areas, the inspectors would take a sample in one location and then attribute the properties of that sample to other materials in the building. One problem with the report format was that the same sample number appeared repeatedly in the tables and on several drawings, with no indication of where the sample was actually taken. They compounded the confusion by mathematically compositing sample results. This sometimes made it impossible to find the location of bulk samples from the information in the reports when going through the buildings. When preparing a report, it helps to put yourself in the position of the person who will have to use it.

One of the projects this firm was sued for involved a sixteen-story office building that they inspected and for which they subsequently designed and managed an abatement project. The inspectors encountered some of the "institutional limitations" to access mentioned earlier, with the result that seven floors were not inspected. For those floors, spreadsheets were not generated because no samples were taken. Therefore, no estimate of the quantities of ACM on those floors was produced and the amount of ACM in the building was vastly under-reported. The owner relied on this under-estimate as the basis for the costs of the subsequent abatement and sued the consultant for "missing all that asbestos." A large part of the ACM that was omitted consisted of thermal system insulation in pipe chases.

This case drove home the lesson that functional spaces and homogeneous areas must reflect the three-dimensional nature of a building. A pipe chase is a vertically oriented functional space in its own right, not part of the floors it passes through. Even if a pipe chase isn't accessible on every floor, the pipes extend the length of the chase and extrapolation may be needed to determine the total quantity in the chase. A spreadsheet won't do this unless you tell it to.◆

with Section 508 of the Rehabilitation Act of 1973 [4]. This law requires electronic media to be accessible to the visually impaired, and that includes people who are color-blind. If the red line on a drawing is a steam pipe and the green one is a condensate line, they also need to be labeled as such to be "508-compliant."

The Baseline Survey report should provide enough information for the building owner to formulate and implement a long-term asbestos management program. Part of this program will include abatement, for which the Project Design Survey described in the remainder of this chapter provides essential information.

Project Design Surveys

The purpose of the Project Design Survey is to provide information for the project designer to use in preparing plans and specifications for an abatement project. It is the foundation of a well-executed project design, so we need to understand it thoroughly.

Why do another survey? Can't a project be designed from the Baseline Survey report, or even the report from a Limited Asbestos Screen? The answers are "probably not" and "certainly not." In fact, why even prepare a project design—can't you just give the contractors the survey report and ask them for bids? Some survey reports contain express prohibitions against using the document to solicit bids for an abatement project, but this admonition is often ignored. Except for schools, no federal law requires plans and specifications for an abatement project, but any documents serving that purpose must be prepared by an accredited project designer. In some states, a project design is required and the person who prepares it must be licensed. Texas goes as far as to require the project designer to sign the drawings and every page of the specification [5].

There is a reason that ASTM E 1368 and ASTM E 2356 were assigned to Committee E06 on Performance of Buildings: this committee is responsible for ASTM construction standards. Asbestos abatement is construction work, all of the health and environmental ramifications notwithstanding. Nonetheless, owners who wouldn't think of constructing or renovating a building or facility without involving an architect or engineer are willing to turn an asbestos abatement contractor loose without having plans and specifications prepared by an accredited project designer. The practice is more prevalent, though by no means restricted to, the industrial sector. An important *caveat* is in order for those who take this approach. The building owner will want someone to prepare a written description of the work to be done, and few building owners or abatement contractors have accredited project designers on staff. How much detail can be put in these documents without running the risk of a regulator concluding that someone has engaged in "project design" without being properly accredited and maybe licensed? When does a marked-up floor plan become an abatement drawing and a removal procedure becomes a specification? These are gray areas an owner may be treading at his peril.

A Limited Asbestos Screen does not provide sufficient information to design even the smallest abatement project. Even if a Baseline Survey has been performed, the information may be inadequate and the Project Design Survey compensates for its limitations in several ways:

- Destructive testing is not performed in a Baseline Survey. An abatement project that precedes renovation or demolition has to remove ACM that would be exposed when concealed spaces are opened by the general contractor or sub-contractors. These spaces will be inspected during the Project Design Survey. Figure 20 shows an inspector looking through a hole made in a solid ceiling and Fig. 21 shows what he found in the plenum. You would not want the pieces of pipe insulation—let alone the masonry block—to come down on the heads of the general contractor or a sub-contractor who demolishes the ceiling during a renovation. An abatement contractor should take this ceiling down, even if the plaster doesn't contain asbestos (this one didn't), or at least as much as is needed in order to remove the asbestos pipe insulation.
- Some materials were assumed to be ACM—or treated as PACM according to the OSHA regulations—and not

Fig. 20—Inspecting plenum above a plaster ceiling.

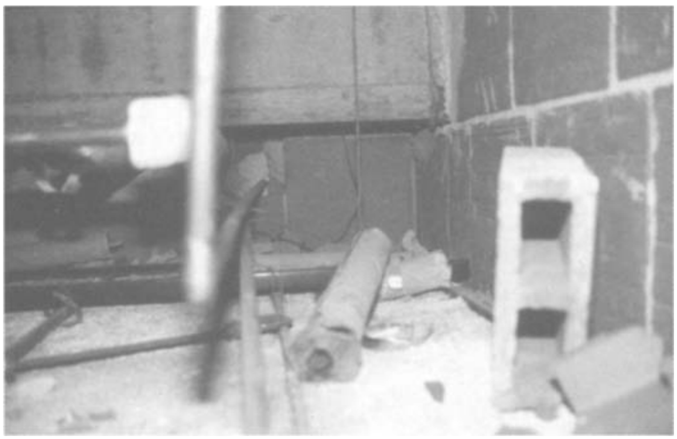

Fig. 21—Pipe insulation and construction debris in plenum.

sampled for aesthetic or other reasons. Removing them as ACM costs far more than leaving them in place or removing them during the course of ordinary construction. It is worth taking some samples and analyzing them to find out if they really do contain asbestos.

- Access may have been denied to some functional spaces during the Baseline Survey for reasons described earlier as "institutional limitations." If a space is to be renovated, or the building demolished, the occupants have to move out eventually, at which point the area will be accessible. Also, once they know they are moving out, occupants won't be as concerned about holes in the walls or the carpeting that is pulled up. If the space has been vacated when you arrive to do the survey, be prepared to find that the lights and power have been turned off.
- Some materials may not have been sampled and spaces not inspected during the Baseline Survey for reasons of safety and cost. Inspecting the ceiling of an auditorium may require a powered man-lift, an expensive item to rent and something the owner may have reservations about bringing into the building. Using one requires proper training, there are liability and insurance issues, and working at elevated locations comes under the OSHA fall protection regulations. Utility vaults, some crawl spaces and certain industrial enclosures qualify as confined spaces, which require testing of the atmosphere inside and rescue capability—all of which costs money and requires training. Entering some spaces—confined or otherwise—may require de-energizing electrical circuits or de-pressurizing steam lines, steps that the owner may have been reluctant to take during the Baseline Survey. Faced with an abatement project, the owner should be willing to take the measures needed to inspect these spaces—thoroughly and safely—during the Project Design Survey and recognize the need to provide proper compensation for these efforts.
- The Project Design Survey is limited to the area that will be affected by the abatement project, and it focuses more intensively on that part of the building or facility. In the case of a renovation, the project designer must know the extent of the planned construction. Ideally, the architect or engineer will have already prepared the design documents for the renovation that the project designer can use to design the abatement project. In practice, the renovation design effort is still a work in progress and the project designer has to make a concerted effort to find out exactly where ACM might be disturbed during the renovation. The closer you can work with the architect or engineer, the more accurate and complete will be the plans and specifications for the abatement project, and fewer will be the surprises during abatement and renovation. Especially important are the demolition drawings, and it helps to remember that there are two definitions of demolition. The demolition drawings prepared by an architect show the removal of interior walls, chases and ceilings that in most cases are not load bearing. Engineers use demolition drawings to show mechanical components to be removed. Both types of demolition drawings are important for the project designer in locating ACM that may have to be abated. This is different from demolition in the NESHAP sense of the word—taking out load-bearing members of a building.

Considering the above, the approach to a Project Design Survey is similar to a Baseline Survey in many respects. The fundamentals of planning, field work and sample analysis still apply. Instead of a survey report, however, the end product of a Project Design Survey is the plans and specifications for an abatement project.

Sometimes a little extra effort during the Project Design Survey can save a lot of time and money later. In one building, there was a small mechanical room (Fig. 22) and two restrooms with acoustical plaster that appeared similar to that on ceilings in the adjoining spaces where samples had shown asbestos to be present. The mechanical room had about 20 ft^2 (1.85 m^2) of plaster, and also an HVAC unit, ductwork up against the ceiling, a suspended light fixture, electrical panels, a sink, and shelving, as well as conduit and pipes attached to the ceiling and covered with plaster. If this room was abated, all of these items would have to be cleaned and/or protected. The restrooms had less than 100 ft^2 (9.3 m^2) of plaster and a lot of surfaces to protect and clean if the rooms were abated. The owner agreed that it was worth the cost of taking a few extra bulk samples of the plaster in these rooms. The samples contained no asbestos, and the rooms were excluded from the scope of work. The cost of preparation, removal, visual inspection and clearance for these small rooms was thus eliminated.

The phrase "Field work consists of collecting samples and information" is as true of a Project Design Survey as a Baseline Survey, with perhaps more emphasis on informa-

Fig. 22—Ceiling plaster inside mechanical room was not ACM.

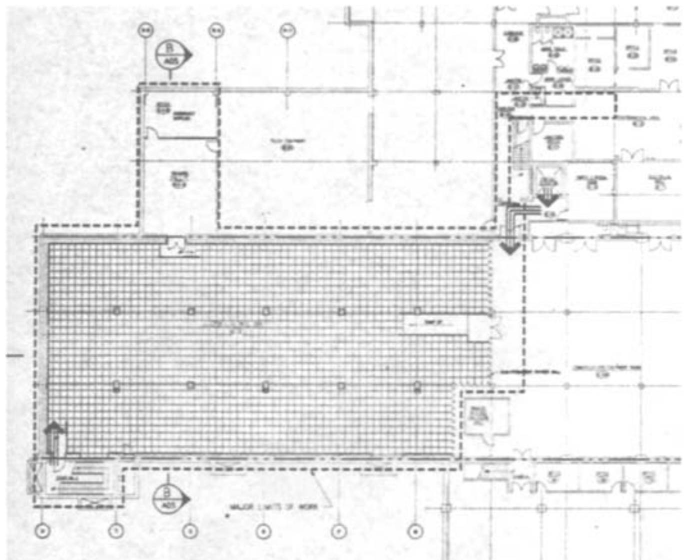

Fig. 23—Limits of construction on a renovation drawing.

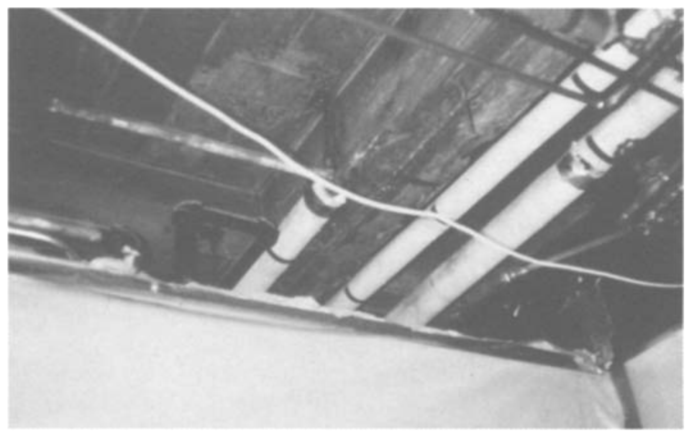

Fig. 24—Pipes extending across wall into adjacent unabated space.

tion than on samples. ASTM E 2356 covers eighteen items that have little or nothing to do with bulk sample results, some of which are discussed below. The project designer needs this information, however, to prepare the plans and specifications.

Limits of Abatement and Phases of Work

These subjects head the list of items in ASTM E 2356 because they define the physical and temporal boundaries within which the abatement will take place. For abatement preceding renovation, they are intimately tied to the general contractor's construction schedule; that is why the architect's or engineer's plans are so important to the project designer.

A typical renovation drawing will show the limits of construction as in Fig. 23. The dashed line is labeled "MAJOR LIMITS OF WORK" and all ACM within these limits must be removed before construction begins. It sounds simple to find the walls defining the "limits of construction" and make them the "limits of abatement," but sometimes only part of a floor is renovated and insulated pipes and fireproofed beams and decks cross the walls where the renovation will stop. In order to construct the critical barriers, some of the ACM outside the limits of construction has to be removed and the limits of abatement expanded to include this material. Figure 24 shows pipes running across the top of a wall above the ceiling into an adjacent space not scheduled for renovation. Since straight runs of pipe insulation are installed in discrete lengths, usually about 3 ft (1 m), it is generally easier to remove it at the butt joints instead of cutting through it in the middle. This also reduces fiber release, of course. To do this, one may have to extend the limits of abatement into the adjacent space to the first accessible butt joint in the insulation, remove the insulation to that joint and wrap or seal the exposed end. This can be done using glove bags, mini-enclosures, or both, and the specification should describe these methods.

Buildings are three-dimensional objects and renovation on one floor can affect ACM on adjacent floors. Radiators and fan coil units are connected to pipes below the floor and the pipes must either be cut above the slab on top or below the deck (Fig. 25). Doing the latter may mean removing enough insulation for the plumber to cut the pipes on the floor below the renovation work, and maybe contending with fireproofing in the plenum. The limits of abatement now include another floor.

Ductwork, elevator shafts, escalators, chases and stairwells span floors, and the vertical extent of a renovation—and the associated abatement—will often encompass areas

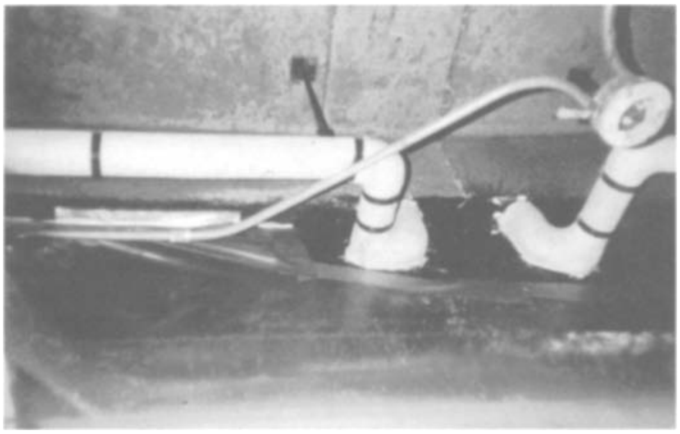

Fig. 25—Pipes underneath floor slab connect to a heating unit above.

above and below the primary working level. At the perimeter of the building, there will be gaps between the curtain wall and structural members or the floor slabs that may require abatement of fireproofing or pipe insulation on the floors above and below. The limits of abatement can get complex rather quickly.

Renovation often proceeds in phases across a floor and from floor to floor. The abatement that precedes the renovation must stay at least one area ahead, and successive phases of abatement may take place in areas that are contiguous or separated. Coordinating abatement and renovation work in the same building offers challenges, not the least of which is keeping the construction tradesmen from disturbing ACM before the abatement contractor has a chance to remove it. If an area is not ready for renovation because the abatement contractor didn't finish on time, expect the general contractor to submit a claim for delay charges.

Removal of Concealed ACM

Figure 26 shows schematically some locations that should be inspected for concealed materials. All but one would require destructive testing to find. The plaster ceiling above the lay-in ceiling (also see Fig. 27) should be found during a Baseline Survey by lifting the tiles.

The time to anticipate the existence of concealed ACM is during the Project Design Survey, as the following example illustrates.

A project involved removal of acoustical plaster from a vaulted ceiling in a former airport terminal (Fig. 28). A drawing prepared by the building owner (Fig. 29) showed a floor plan with the note "Indicates area of asbestos-containing ceiling material to be removed" applying to the shaded area. This is a common way of designating the removal requirements and usually oversimplifies the situation. The vaulted ceiling contained most of the material, with the remainder being on a flat ceiling extending to the right in Fig. 28. It sounded like a simple ceiling scrape, and that is how the contractor bid the job.

A closeup of the light trough at the base of the vaulted ceiling is shown in Fig. 30. Unfortunately, no detail was

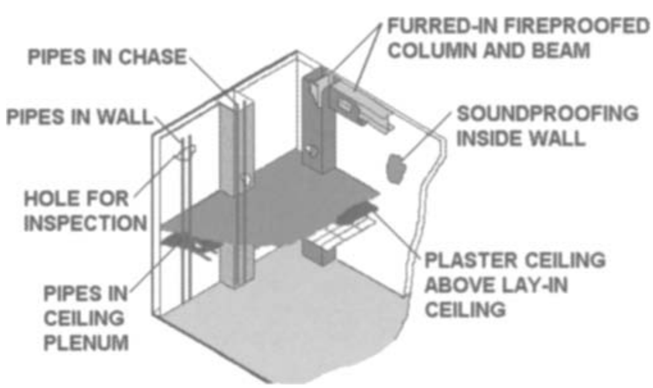

Fig. 26—Typical locations of concealed ACM.

Fig. 27—Plaster ceiling above lay-in ceiling.

Fig. 28—Vaulted ceiling of former airport terminal.

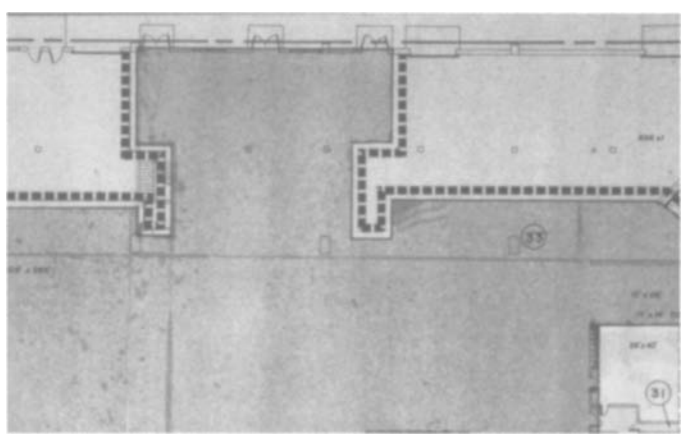

Fig. 29—Airport terminal asbestos abatement drawing.

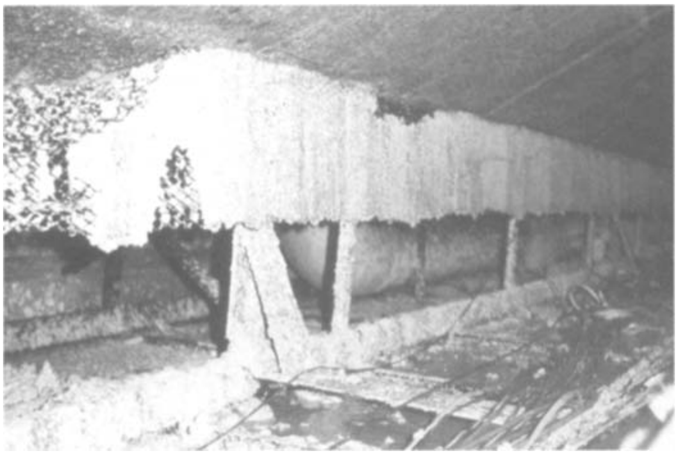

Fig. 30—Top of light trough with overspray in plenum behind fascia.

provided on the drawing to tell the contractor that there was a plenum with overspray on ducts, pipes, and joists that the owner expected him to remove. The contractor objected strenuously and futilely to the owner's insistence that the metal lath fascia behind the light trough be removed and other necessary steps be taken to get to the overspray at no additional cost. The result was a considerable delay in the project and hard feelings all around.

Emergencies and Essential Services

An occupied building must keep functioning during the abatement project. People have to get in and out, and the building's systems must continue to operate. The only exception is the area where the abatement is taking place, and sometimes there are exceptions to that exception.

Emergencies

During the Project Design Survey, think about the following issues:

- How would the crew escape from the enclosure in case of a fire or other emergency?
- Where are the nearest building exits and fire alarms?
- How would rescuers get *into* the enclosure if they had to?
- Once the enclosure is in place, how would occupants exit the building in event of an emergency?

Some codes require at least two escape routes from any point in the building, and the contractor cannot block them with the enclosure or his equipment. The doorway in Fig. 31 would not be a good place to put a decontamination facility—stairwells are another poor location.

Building Systems

HVAC systems serving the space inside the enclosure must be turned off, while the rest of an occupied building continues to be heated or cooled. HVAC systems need to be balanced and turning off the airflow to one part of the building can affect airflow to another part. During the Project Design Survey, show the building engineer the areas where the enclosure will be set up so he can plan the temporary changes to the system. This is the building owner's responsibility—the abatement contractor should not have to touch the HVAC system.

The same goes for the electrical system—the building electrician, not the abatement contractor, should turn off

Fig. 31—Emergency exit and fire hose cabinet must be kept clear.

power to circuits that will be inside the enclosure. If any electrical panels or circuits in the enclosure must remain in service, the project designer might have to figure out a way to protect them and possibly provide access while abatement is in progress. The panels in Fig. 32 were isolated from the enclosure by a temporary wall, which allowed cooling air to be introduced and also provided access for maintenance.

Find out if any energized systems—steam or water lines, fire sprinklers, compressed air lines, machinery, etc.—must remain in operation inside the enclosure. These can be extremely hazardous to the abatement workers and every effort should be made to have them de-energized. There may be some lines—such as oxygen in a hospital and fire sprin-

Fig. 32—Metal studs for temporary wall around electrical panels.

klers—that must remain operational, necessitating special precautions when working around them.

Modern buildings have an abundance of special equipment for security, telecommunications and other purposes. If these are located where the enclosure will be built, they must be temporarily moved or means devised for the building owner's staff to access them and keep them operating.

Enclosures and Decontamination Facilities

Establishing the limits of abatement determines where the negative pressure enclosure will be located, although the details of their layout and construction are best left to the contractor. It still behooves the project designer to have a general idea at this point where the decontamination facilities and the negative air machines[7] will be located.

Operating a negative pressure enclosure (see Chapter 4) and its decontamination facilities takes water and power. Locate available sources of water for the decontamination facilities as well as for use within the enclosure during removal and cleanup. If it is a long way from the hose bib to the enclosure, the hose is more susceptible to damage and the pressure drop increases. If no suitable source can be found near the enclosure, the contractor may have to position a mobile water tank, keep it full and pump the water to the enclosure (Fig. 33).

Equally important is getting rid of the water after it is used. Water inside the enclosure is supposed to be combined with the removed material or another absorbent. Shower water goes through a set of filters and into a floor drain or sink to a sanitary sewer as long as local regulations permit. During the Project Design Survey, look for a suitable connection and if none can be found, consider another way that the water can be legally disposed of.[8]

The negative air machines draw a lot of power as do the contractor's lights, spray pumps, electric lifts, etc. With the assistance of the building electrician, find a panel outside of the enclosure from which leads can be brought out to connect to the contractor's power panel. A negative air machine rated at 2000 ft^3/min (56 m^3/min) draws 15 amps, and having a rough idea of the size of the enclosure will tell you about how many machines will be needed. If power is not available close to the enclosure, the contractor may have to site a portable generator (Fig. 34), and consideration should be given to noise, exhaust ducting and fuel storage.

Regulations require that the exhaust from negative air machines be discharged outside the building *when feasible*. When is it not feasible? If the exhaust duct has to be so long or have so many turns that the pressure drop is excessive, the airflow through the machine is impaired and the performance of the negative pressure enclosure (air changes per hour and pressure differential) suffers. If this situation exists, find an unoccupied space into which the exhaust can be dumped and where a high-volume air-sampling pump can be set up.

Contractor Accommodations

The contractor needs space near the enclosure for what is called the "mobilization area." This is where equipment and supplies are stored and the supervisor sets up a temporary "office." Find an area that is accessible for the contractor without having to traverse occupied parts of the building, preferably near a loading dock or service entrance. It should be possible to secure this area against entry when the contractor is not on site. If restroom facilities on the premises will not be available to the abatement workers, the contractor will have to site portable sanitation units.

Find a location conveniently accessible to the mobilization area where the contractor can store containers of removed material and contaminated waste awaiting disposal, and where the material can be picked up by the waste transporter. If a waste container such as a Dumpster™ is positioned outside the building, it must be in a secure location and not interfere with entry and exit by building occupants.

Asbestos being the sensitive topic that it is, the building or facility owner may want occupants to see as little as possible of the abatement activities. Of course, they won't be

Fig. 33—Portable water tank used during abatement project.

Fig. 34—Portable generator supplying power for abatement project.

[7] The vernacular for the HEPA-filtered ventilation units used to produce a negative pressure in the enclosure relative to the surrounding space. They are called Air Filtration Devices and several other names, but "negative air machine" seems to have stuck.

[8] On one project, there was no alternative to letting it run into an open ditch. In Austin, Texas, which sits atop the environmentally sensitive Edwards Aquifer, this could have become a public relations issue. A sample of the water coming out of the shower filter was tested and contained fewer asbestos fibers than the 7 fibers/mL allowed by the EPA drinking water standard. (EPA Method 100.1 / 100.2—Asbestos in Drinking Water.)

able to go inside the enclosure, but the owner may ask for "visibility barriers" that shield the mobilization area from view. These barriers need only have ordinary construction area warnings, not the OSHA "DANGER—ASBESTOS" signs. Besides reducing apprehension and enhancing security, these barriers provide some privacy for workers who tend to suit up and dress in the mobilization area, outside the clean room of the decontamination facility. The clean room in Fig. 35 is nowhere near large enough for the crew to change clothes.

Don't forget the consultant and project monitor. They need a secure place to keep their equipment, which may include a Phase Contrast Microscope for analyzing air samples. To avoid potential contamination of the air samples, this temporary office should be well removed from the enclosure and other sources of asbestos fibers.

Finally, many buildings have security provisions that all persons working on the abatement project must comply with. Find out what these are during the Project Design Survey so that all affected individuals can be informed in a timely manner, and identify any restricted areas on the premises that must be avoided.

Material Testing and Inspection

The physical condition of the ACM may be an issue for project design, and not just in the context of the assessment that will be discussed in Chapter 3. It may be necessary to perform testing of the ACM during the Project Design Survey and to make careful observations of the substrate.

The decision of whether to remove surfacing material may rest on the integrity of the material if abatement is contemplated for reasons other than renovation or demolition. If encapsulation is to be used as an abatement method or as an adjunct to removal, the ability of the ACM to withstand encapsulation must be determined. ASTM methods for testing the cohesion of the material—its internal strength—and its adhesion to the substrate are discussed in Chapter 5. Because these tests can release asbestos fibers, they should be done in an unoccupied area with personal protective equipment.

Look closely at the condition of the substrate where it is visible, at the surface of fireproofing for spots that indicate rusted steel underneath (Fig. 36), and at the underside of ceilings and roof decks (Fig. 37) for evidence of water leaks.

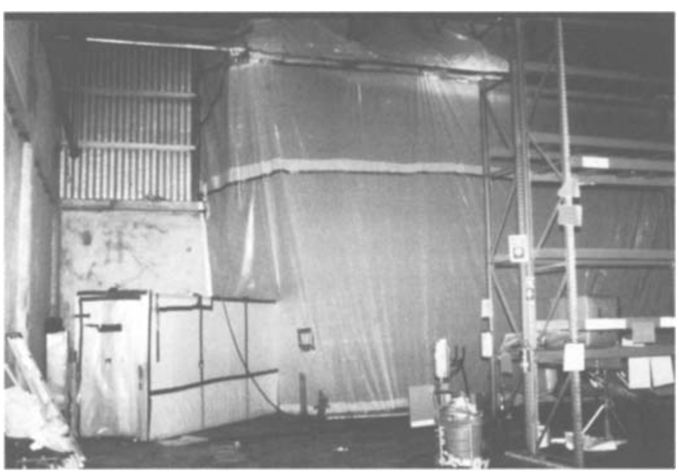

Fig. 35—Contractor's mobilization area — clean room is last section of decontamination facility.

Fig. 36—Rust spots on fireproofing indicate condition of substrate.

These are indications of possible difficulties that the contractor may face during removal, which are discussed further in Chapter 4, and are best identified during the Project Design Survey.

Quantification of ACM

Prospective contractors for the abatement work are responsible for determining quantities on which to base their bids, but the project designer is expected to provide a reasonable estimate in the bid documents. It is essential that no major locations, such as an entire room, be overlooked in the project designer's estimates. However, differences in quantities for complex configurations of structural steel, as in Fig. 13, or piping installations (Fig. 38) may be expected.

The Project Design Survey should clearly indicate whether pipe fittings are enumerated separately or included in the overall length of pipe along with the straight runs of insulation. If the fittings contain asbestos but the straight runs do not, the owner may decide to have the straight runs removed anyway, and as they would be removed and disposed of as ACM they would be included in the total. Because removal costs for pipe insulation depend on size, the outside diameters of the insulation should be recorded.

The Project Design Survey should provide all of the information needed to fully describe the ACM to be

Fig. 37—Roof leak caused rusting of deck and beam.

Fig. 38—Mechanical room pipes have short runs and many fittings.

removed, whether it is readily accessible or concealed. It should also document the ACM in areas to undergo abatement that will remain in place. All of this information will find its way into the plans and specifications and be shared with prospective abatement contractors during the Pre-Bid Conference.

References

[1] EPA 560/5-85-030A, Asbestos in Buildings: Simplified Sampling Scheme for Surfacing Materials ("Pink Book"), U.S. Environmental Protection Agency, Washington, D.C.1985.

[2] Rasnic, J. B., Clarification of Asbestos NESHAP Requirement to Perform Point Counting, U.S. Environmental Protection Agency, letter dated May 8, 1991.

[3] Perkins, R. L. and Harvey, B. W., "Method for the Determination of Asbestos in Bulk Building Materials," EPA-600/R-93/116, Research Triangle Institute, Research Triangle Park, NC. July, 1993.

[4] Section 508 of the Rehabilitation Act of 1973, as amended, 29 U.S.C. §§ 794 (d) Electronic and information technology (Rehabilitation Act Amendments of 1998).

[5] Texas Asbestos Health Protection Rules, §295.47 Licensure: Individual Asbestos Consultant. Texas Department of Health, Austin, TX. March 2003.

3 Assessment of Asbestos-Containing Materials

ONE IMPORTANT PART OF A BASELINE SURVEY, which was covered in Chapter 2, is the assessment of the ACM. Assessment is the process of evaluating the condition of the ACM at the time of the survey and predicting what could happen to make the condition worse. The decision to remove ACM is based on this assessment as well as the type and quantity of the ACM and other factors. This chapter provides a detailed discussion of the assessment protocols in ASTM E 2356, which offer a significant improvement over methodologies that have been in use for a number of years. In particular, the ASTM E 2356 assessment protocols differ from the "AHERA protocol" in several respects. Those who have become accustomed to using the "AHERA protocol" and wonder why ASTM E 2356 takes a different approach should read the sidebar on page 25 and start "thinking outside the AHERA box."

ASTM E 2356 describes two assessment protocols—one qualitative and one quantitative. The qualitative protocol lends a twist to the "AHERA protocol" that eliminates all limitations on the types and locations of materials assessed. The quantitative protocol does the same thing, but the use of numerical assessment ratings makes the process more precise and is more conducive to tabular and graphical presentation of the results. Both protocols culminate in prioritizing response actions—abatement and O&M—but do not specify which ones are required in the manner that the AHERA regulations do.

Because the hazard of inhaling asbestos fibers requires that they become airborne, the assessment is a process of predicting *fiber release*. The two characteristics of ACM that are most indicative of the potential for fiber release are its current condition, reflecting what has already happened to it, and the potential for disturbing it, a prediction of what is likely to happen in the future. Every homogeneous area of friable and non-friable suspect or confirmed ACM is assessed as to its *Current Condition* and *Potential for Disturbance*, either qualitatively or quantitatively.

Qualitative Assessment Protocol

Qualitative assessment of ACM is an extension of one of the topics taught in Asbestos Awareness courses, which §763.92 of the AHERA regulations describes as "Recognition of damage, deterioration, and de-lamination of ACBM." In assessing the Current Condition, the inspector not only recognizes damage and deterioration (from de-lamination and other causes) of ACM, but describes and ranks these factors. Another component of awareness training is avoiding damage so that intact materials remain undamaged and damaged materials don't get worse. The training courses pose the question "What caused that to happen?" to illustrate behavior that the employees should avoid. Past behavior being such a good predictor of future behavior, the inspector can ask the same question during the survey and use the answer to formulate the Potential for Disturbance ranking.

Current Condition

Based on visual observation, which may include touching to determine friability,[1] the inspector categorizes the material as being in "Good," "Fair," or "Poor" condition according to the criteria shown in Table 1.[2] If debris is observed, the assessment of the homogeneous area that is the source of the debris should reflect the presence of the debris.

Within each qualitative ranking there exists a continuum of current condition. Thermal system insulation in "Good" condition may be completely "intact," meaning that the covering is not torn, or "substantially intact." According to the OSHA Construction Industry standard, "*Intact* means that the ACM has not crumbled, been pulverized, or otherwise deteriorated so that the asbestos is no longer likely to be bound with its matrix." This sounds a lot like the definition of *Nonfriable* in the AHERA and NESHAP regulations. OSHA also uses the intriguing term "substantially intact" in two places in the regulations without defining it. A piece of floor tile in its original size, or the size it was cut to for installation, is "intact." Break it in two, and both pieces are still "intact" by OSHA's definition. Therefore, a floor with a few pieces of broken tile could still be assessed as in "Good" condition.

At some point beyond "substantially intact," the ACM is assessed in "Fair" condition, depending on the amount of damage and debris visible. ACM in "Poor" condition makes no pretense of even being "substantially intact."

Figures 41–43 show, respectively:

- Pipe insulation in "Good" condition with the covering intact except for two elbows cut away to make room for the uninsulated vertical pipes
- Pipe insulation in "Fair" condition with damage to the covering and exposed ends
- Pipe insulation in "Poor" condition with the covering extensively damaged

Figures 44–46 show, respectively:

- Fireproofing in "Good" condition that is intact except for where the clamps supporting the light fixture attach to the flange

[1] Friability is an intrinsic characteristic of the material, but non-friable materials that are damaged or deteriorated are to be treated as friable according to the NESHAP. Such damage or deterioration to non-friable materials (usually miscellaneous) would be reflected in their condition assessment.

[2] Tables 1–4 are taken from Appendix X2 of ASTM E 2356.

Table 1—Qualitative rankings for current condition.

Qualitative Ranking	Description of Current Condition	AHERA Analogy
Good	Surfacing material has no visible damage or small amounts of damage; covering on thermal system insulation is intact or has small amounts of damage; miscellaneous materials are intact or have small amounts of damage; no visible debris or small amounts of debris.	Undamaged
Fair	Surfacing material has moderate but not extensive amounts of visible damage; covering on thermal system insulation is cut or torn, exposing moderate but not extensive amounts of insulation; moderate but not extensive damage to miscellaneous materials such as floor tile; moderate but not extensive amounts of visible dust and debris.	Damaged thermal system insulation Damaged friable surfacing material Damaged friable miscellaneous material
Poor	Extensive damage to surfacing material; covering on thermal system insulation is cut or torn extensively and insulation itself is damaged; miscellaneous materials such as floor tile extensively damaged and underlying mastic exposed; extensive amounts of debris.	Significantly damaged friable surfacing material Significantly damaged thermal system insulation Significantly damaged friable miscellaneous ACM

Fig. 39—Note damaged floor tiles under table.

Fig. 40—Power plant deaerators and pipes insulated with asbestos.

Fig. 41—Pipe insulation in "Good" condition.

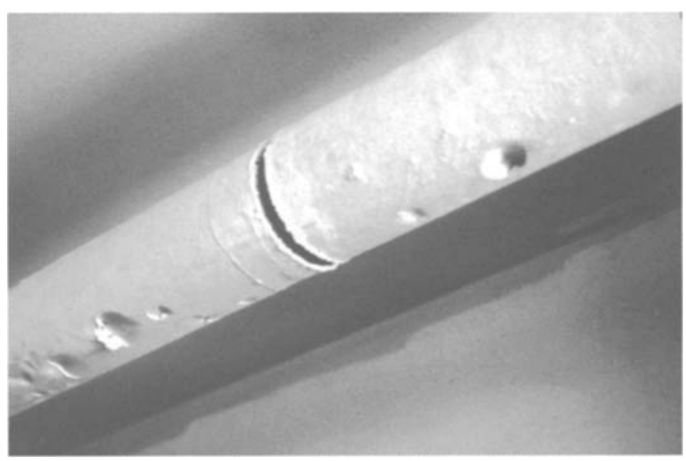

Fig. 42—Pipe insulation in "Fair" condition.

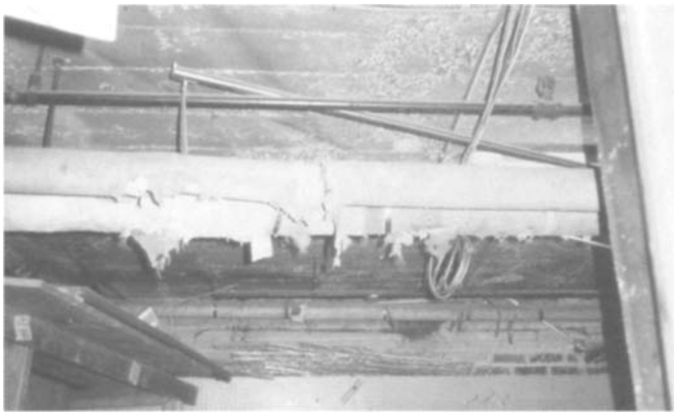

Fig. 43—Pipe insulation in "Poor" condition.

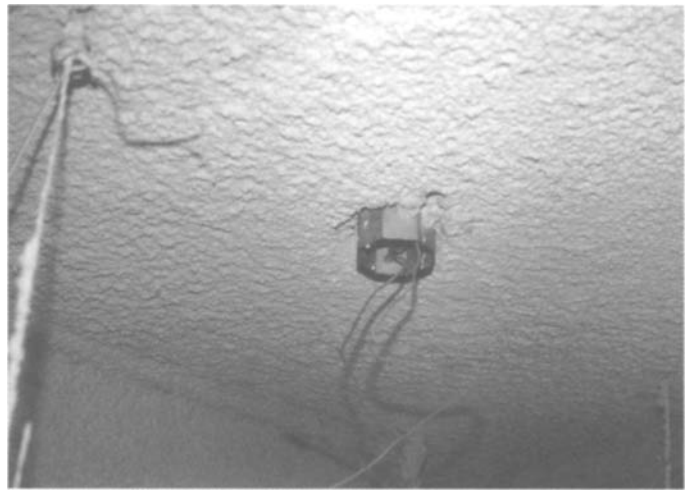

Fig. 45—Fireproofing in "Fair" condition.

Fig. 44—Fireproofing in "Good" condition.

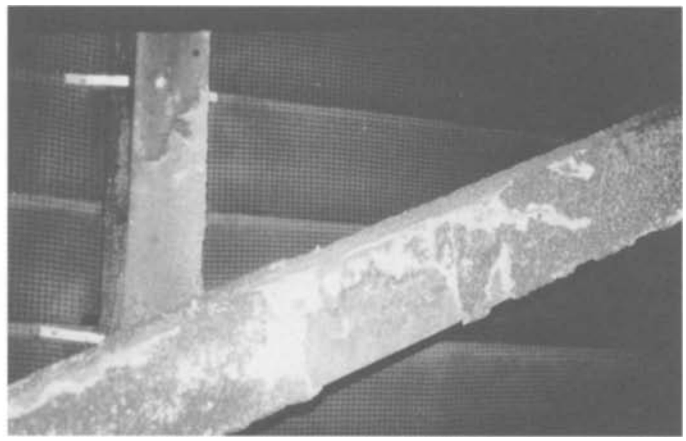

Fig. 46—Fireproofing in "Poor" condition.

- Fireproofing in "Fair" condition on a deck where it has been scraped to install a junction box and hanger straps
- Fireproofing in "Poor" condition that has become delaminated from the column and girder, generating extensive debris

These assessments, of course, represent one person's opinion and other qualified inspectors may decide to categorize these examples differently. Assessment of ACM is, after all, a matter of professional judgment.

The analogous AHERA damage categories are listed in Table 1 as an aid to determining the qualitative rankings. Five of the seven AHERA damage categories are listed and are also broken out as to the type of ACM: surfacing material, thermal system insulation and miscellaneous material. Because the "current condition" assessment shows the ACM as it exists during the survey, not what could happen to it in the future, the fifth and sixth AHERA categories—potential for damage and potential for significant damage—are not relevant. Damage thresholds such as the 10% and 25% rules for localized and distributed damage (see ***The AHERA Protocol***) may be used as a guide to classifying the current condition of ACM, but it is worth remembering that within each ranking a continuum of conditions will be found.

Sidebar 1—The AHERA Protocol

In a Chapter 2 sidebar titled ***"When Is ACM Not ACBM?"*** we started to realize how ASTM E 2356 goes beyond the "AHERA Protocol" for collecting bulk samples. A similar situation prevails in the assessment of ACM, and if we are to appreciate the benefits of the ASTM E 2356 approach, it helps to understand this aspect of the "AHERA Protocol" that people are so fond of citing. In doing so, we can also clear up some misconceptions about the "AHERA Protocol."

The section of the AHERA regulations that prescribe how ACM is to be assessed is titled §763.88 – Assessment. It requires that the physical condition of friable asbestos-containing materials be classified by the inspector into one of seven categories:

(1) Damaged or significantly damaged thermal system insulation ACM
(2) Damaged friable surfacing ACM
(3) Significantly damaged friable surfacing ACM
(4) Damaged or significantly damaged friable miscellaneous ACM

Sidebar 1—The AHERA Protocol—*continued*

(5) ACBM with potential for damage
(6) ACBM with potential for significant damage
(7) Any remaining friable ACBM or friable suspected ACBM

The terms in these categories are defined in §763.83—Definitions of the regulations. The difference between "Significantly damaged" and merely "Damaged" is that the former is "extensive and severe."

Once the physical condition of the ACM has been assessed by the inspector, the management planner takes over and determines response actions according to the section titled §763.90—Response Actions. This section directs the Local Education Agency (LEA) to take action ranging from immediate isolation and removal of significantly damaged friable surfacing ACM (category 3) or significantly damaged friable miscellaneous ACM (category 4) to implementing an O&M program or taking other measures for the remaining categories. Category (7), however, is not mentioned in this section.

In four separate paragraphs the regulations specify the assessment of *friable* ACBM. The omission of the word "friable" from categories (5) and (6) leads some to conclude that *non-friable* ACBM in these categories should be assessed. However, EPA has specifically stated that "Nonfriable miscellaneous and nonfriable surfacing ACBM *do not* have to be assessed" (*emphasis in original*) [1]. For schools, at least, nonfriable ACM is left out of the assessment protocol.

How are floor tile and siding assessed under the "AHERA Protocol?" Both are nonfriable miscellaneous materials, for which no category exists. If they are damaged to the extent that they have "become friable" they go into category (4) or the catch-all category (7). Some inspectors would maintain that they don't have to assess intact floor tile or siding without realizing that the act of determining the materials are intact constitutes an assessment. ASTM E 2356 avoids this Catch-22 situation.

Bear in mind that the AHERA regulations have not been revised since they were published in 1987 and the "AHERA protocol" reflects the regulatory exclusions as to what materials must be assessed. These restrictions are sometimes erroneously cited as *prohibiting* assessment of such materials in any type of building. Just because the "AHERA protocol" says these materials *don't have to* be assessed doesn't mean they *shouldn't*, and in many cases it is important to do so—even in schools. Figures 39 and 40 are examples of ACM that would not be assessed under the "AHERA protocol" even though doing so is important for determining appropriate response actions. An inspector who didn't assess the floor tile in Fig. 39 might not notice that condensate from a vending machine on the other side of the wall leaked into this room and loosened the tiles. The insulation on the components in Fig. 40 would not be assessed because they are outside of a building.

The accreditation and training requirements of AHERA are the *only* provisions that were extended to buildings other than schools by the Asbestos School Hazards Abatement Reauthorization Act (ASHARA) of 1990. Nonetheless, many aspects of the AHERA regulations have been accepted as the "standard of care" in asbestos control, including the "AHERA protocol" for assessing asbestos-containing materials.

An entire generation of students has passed through the nation's schools since the AHERA regulations went into effect. Along the way various methodologies have become enshrined as the "AHERA protocol" on the mistaken assumption that they are called for in the regulations. What really happened is that these methodologies were developed years ago to implement the requirements in the regulations and have been taught in training courses ever since. They are good practices to follow but do not have the "force of law" that many people attribute to them.

Inspectors are taught, for example, that "damage" is distinguished from "significant damage" according to whether the damage exceeds 25% on a "localized" basis or 10% on a "distributed" basis. Neither these percentages nor the words "localized" or "distributed" appear in the text of the AHERA regulations in the context of damage, nor do the words "good," "fair," and "poor" appear as descriptions of material condition.

Converting the physical condition assessments into response actions has been described in tables, flow charts, "decision trees" and other formats in training manuals, all of which have helped to explain and implement the process. However, it is somewhat misleading to label these methodologies as "AHERA Hazard Assessment" protocols when they are not actually part of the regulations. In fact, the word "hazard" does not appear anywhere in the regulations for the Asbestos Hazard Emergency Response Act, except in the Model Accreditation Plan.

The "AHERA protocol" provides a relatively narrow framework intended for a specific type of building—schools—that has been embellished through interpretations that allow the protocol to be used in practice. These interpretations are what people actually describe when they refer to the "AHERA protocol" for assessment of asbestos-containing materials. Their limitations become readily apparent when applied to non-school buildings and facilities, a problem that ASTM E 2356 was developed to overcome. ◆

Reference

[1] "100 Commonly Asked Questions About The New AHERA Asbestos-In-Schools Rule," Office of Toxic Substances, Office of Pesticides and Toxic Substances, U.S. Environmental Protection Agency, Washington, DC, May 1988.

Potential for Disturbance

"Disturbance" is as defined by OSHA in the Construction Industry standard as ". . . activities that disrupt the matrix of ACM or PACM, crumble or pulverize ACM or PACM, or generate visible debris from ACM or PACM." The inspector assesses each homogeneous area for potential physical and environmental disturbance using the factors shown in Table 2 on page 29. Every homogeneous area will be subject to a combination of these factors. The inspector determines the relative importance of each and arrives at a composite ranking for potential for disturbance as Low, Medium or High. The contributions of physical and environmental disturbance, and their components, should be explained in the survey report. In some cases, physical activity may be the most important factor, while water damage may be more significant in other situations.

Physical Disturbance

One lesson from awareness training is that most damage to ACM is the result of human carelessness, ignorance and indifference. When considering the physical disturbance factors in ranking the Potential for Disturbance, remember that these involve people. Find out of the work practices that resulted in the existing damage still prevail and could make the damage even worse. Four examples illustrate this approach:

- Workers stepped on the pipe fittings to read a gauge above this air handling unit, knocking loose the asbestos "skim coat" on the fiberglass insulation (Fig. 15, Chapter 2);
- The pipe insulation in Fig. 47 was tripped over and stepped on for years, releasing asbestos fibers and debris every time it happened;
- A common method of suspending pipes from a beam involved scraping some fireproofing off the flange and attaching the clamps, as in Fig. 48;
- Finally, there's Joe Kelley. We would like to think he sprayed the fireproofing on the beam and deck in Fig. 49 and signed his work before it dried—but who knows?

Environmental Disturbance

Four causes of environmental disturbance are identified in Table 2.

- *Vibration* can weaken the ACM and also dislodge it when it has lost its strength. This can result in a slow release of dust, as in the attic shown in Fig. 50 that was full of mechanical equipment, or in a sudden fiber release episode, as the pipe in Fig. 51 illustrates.
- The cause that is defined in the AHERA regulations as "air erosion" is further sub-divided in Table 2. Air molecules are not forceful enough to "erode" material in the sense of gouging the surface, but *air currents* might be strong enough to dislodge loose clumps of fibers that are barely hanging onto their neighbors. Erosion is caused by *airborne dust*, and the pictures of dark areas on the ceiling next to an HVAC grill (Fig. 52) reflect the cleanliness of the ducts, or the lack thereof.
- *Water damage* from a leaking roof has caused part of the ceiling and wall plaster in Fig. 53 to delaminate and fall, causing a fiber release episode. Solution? Fix the roof.

Fig. 47—Damaged pipe insulation on floor.

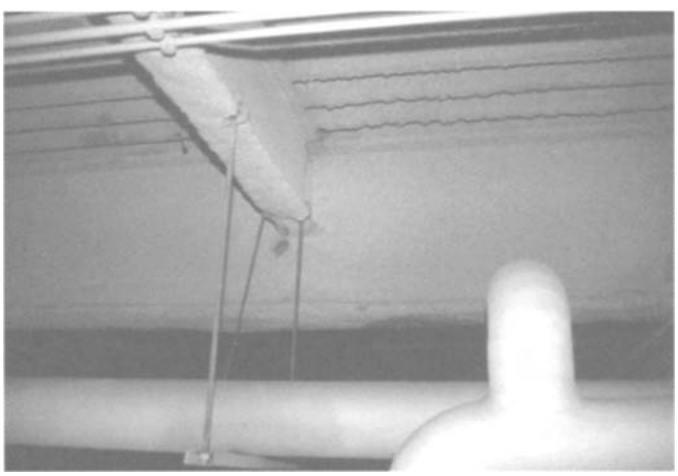

Fig. 48—Fireproofing scraped from flange to attach clamps.

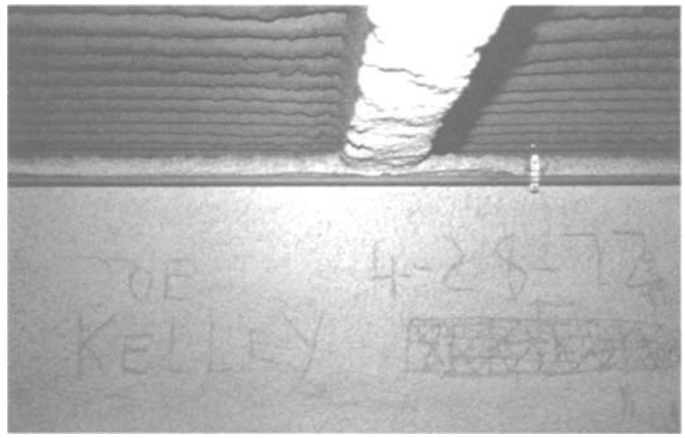

Fig. 49—Who was Joe Kelley and why did he do this?

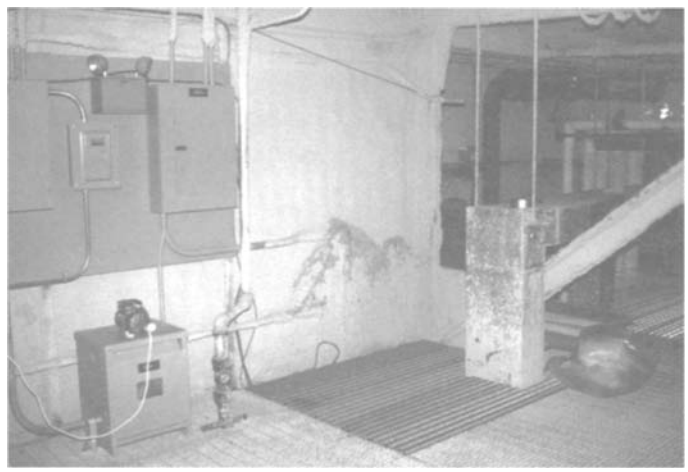

Fig. 50—Dust from fireproofing on floor grates.

Fig. 51—Debris from pipe hanger insulation.

- A *corrosive atmosphere or corrosive liquids* would not ordinarily be found in a school, but try a refinery or chemical plant where all sorts of aggressive liquids drip on the pipes. In one alumina refinery the air was so thick with the caustic used in the refining process that the mastic covering the thermal system insulation on the tanks and vessels was literally eaten away (Fig. 54).

Environmental disturbance can take a long time to happen. The asbestos-cement panels and louvers on the cooling tower in Fig. 55 are Category II ACM under the NESHAP, but if the surface becomes deteriorated they must be treated as friable RACM (Regulated Asbestos-Containing Material). Asbestos-cement roofing and, to a lesser extent, siding is subject to weathering that is mainly due to water and its various chemical contaminants [1]. After many years, exterior surfaces can degrade to the point that asbestos fibers are exposed and released (Fig. 56).

Note that no analogy is given in Table 2 to the AHERA assessment factors as was done for the current condition in Table 1. This is because the fifth and sixth AHERA categories distinguish between *potential for damage*, which exists in all cases to some degree, and *potential for significant damage*. Rather than attempt to predict the severity of the damage that might occur, ASTM E 2356 assesses the likelihood that *any* damage will occur. A Potential for Disturbance rating of Medium would indicate a *potential for damage*, while a rating of High would indicate a *significant potential for damage*. The difference between the ASTM E 2356 approach and the "AHERA protocol" is subtle but significant.

A table of qualitative assessments is of little value for decision-making unless it is properly sorted. Once the assessments for all ACM in the building or facility are tabulated, sort the table by Current Condition according to "Poor," "Fair," and "Good" in that order. Next, sort within each of these categories by Potential for Disturbance according to "High," "Medium" and "Low" in that order. This places the ACM in the worst condition and the most susceptible to further damage (Current Condition="Poor" and Potential for Disturbance="High") in the top rows where it will command the highest priority for abatement. Further down the table are materials in better condition and not as accessible that may be manageable through an O&M program.

Quantitative Assessment Protocol

The Quantitative Assessment Protocol applies numerical ratings to the physical assessment factors—Current Condition and Potential for Disturbance—and tabulates them as dis-

Fig. 52—Plaster ceiling eroded by dust from HVAC duct.

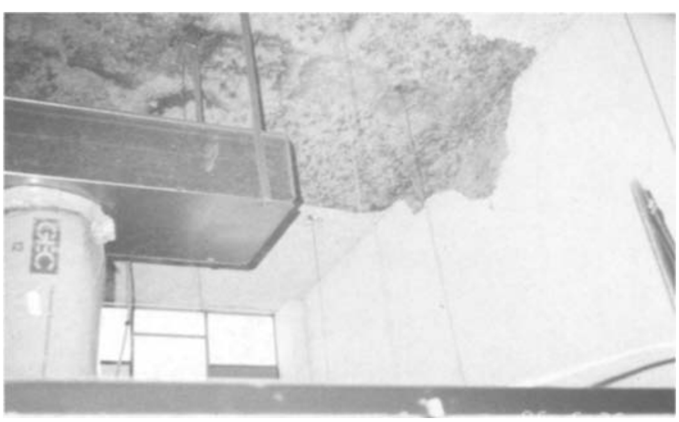

Fig. 53—Plaster ceiling fell due to roof leak.

Fig. 54—Corroded insulation on pressure vessels.

Fig. 55—Cooling tower made with asbestos-cement panels and louvers.

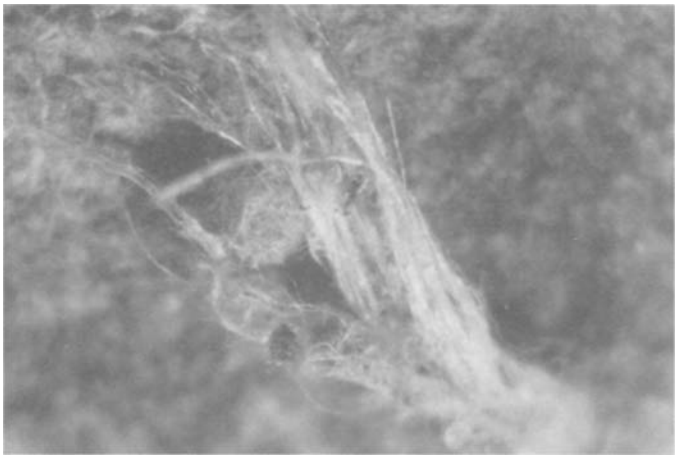

Fig. 56—Microphotograph (38x) of chrysotile fibers in asbestos-cement roofing.[1]

[1] Photograph by James R. Millette, Ph.D., MVA Scientific Consultants.

cussed above. The ratings can also be plotted on an Abatement vs. O&M Decision Chart to prioritize response actions.[3]

To use the quantitative protocol, Tables 1 and 2 are first modified by adding numerical ratings corresponding to the qualitative ranges, as shown in Tables 3 and 4. Note that the scales for Current Condition (CC) and Potential for Disturbance (PFD) work in reverse: CC = 10 describes ACM in virtually perfect condition, while PFD = 10 means that it is highly vulnerable to damage. This is not an impossible situation: if a furred-in chase protecting pipe risers along a busy aisle in a warehouse was to be removed, it would not be long before the currently-intact insulation was damaged.

The following example of a boiler plant illustrates the use of the quantitative protocol. Figure 57 shows twelve examples of thermal system insulation in the plant. Table 5 identifies each picture, lists its location and the type of ACM shown, the CC and PFD ratings and the reasons for the ratings. Tabulating the results in this manner produces

Table 2—Qualitative rankings for potential for disturbance.

Qualitative Ranking			Physical Disturbance		Environmental Disturbance	
Low	Medium	High	*accessibility* during normal operations	*activities* that people do and how often they do them	*vibration* from operating machinery, HVAC equipment, etc.	*air currents* strong enough to dislodge loose ACM *airborne dust* that can erode material
					water damage from leaking roof, pipe or other source	*corrosive atmosphere or liquids* that can erode the covering or matrix

Table 3—Numerical ratings for current condition.

Qualitative Ranking	Numerical Ratings	Description of Current Condition
Good	8, 9, 10	Surfacing material has no visible damage or small amounts of damage; covering on thermal system insulation is intact or has small amounts of damage; miscellaneous materials are intact or have small amounts of damage; no visible debris or small amounts of debris.
Fair	4, 5, 6, 7	Surfacing material has moderate but not extensive amounts of visible damage; covering on thermal system insulation is cut or torn, exposing moderate but not extensive amounts of insulation; moderate but not extensive damage to miscellaneous materials such as floor tile; moderate but not extensive amounts of visible dust and debris.
Poor	1, 2, 3	Extensive damage to surfacing material; covering on thermal system insulation is cut or torn extensively and insulation itself is damaged; miscellaneous materials such as floor tile extensively damaged and underlying mastic exposed; extensive amounts of debris.

Table 4—Numerical ratings for potential for disturbance.

Qualitative Ranking	Numerical Ratings	Physical Disturbance		Environmental Disturbance			
		Accessibility	Activities	Vibration	Air / dust	Corrosive	Water damage
Low	1, 2 or 3						
Medium	4, 5, 6 or 7						
High	8, 9, or 10						

[3] The Quantitative Assessment Protocol in ASTM E 2356 is adapted from the *Customized Compliance Program for Asbestos*, copyrighted by Environment-*i*-media, Inc. (www.environment-i-media.com), and is used by permission.

Fig. 57—Thermal system insulation in boiler plant. Pipes in corner pit **A**. Pipes on platform **B**. Damaged pipes **C**. Debris under tank **D**. Damaged fitting **E**. Steam drum-boiler #1 **F**. Steam drum-boiler #2 **G**. Steam drum-boiler #3 **H**. Steam drum-boiler #4 **I**. Boiler roofing **J**. Radiator pipes **K**. Hot water tank **L**.

Table 5—ACM ranked by current condition and potential for disturbance.

Item (FIG. 57)	Room or Area Shown in Photo	Asbestos-Containing Materials	Assessment			
			Current Condition		Potential for Disturbance	
			Rating	Based on	Rating	Based on
D E	Southwest corner	Tank & fittings insulation	2	Damage & debris	8	Maintenance access
J	Boilers #1, #2 & #3	Roofing	2	Damage & debris	6	Elevated location
K	Restroom	Pipe insulation	3	Debris	9	Close to floor
F G H	Boilers #1, #2 & #3	Steam drum insulation	4	Missing covering	5	Elevated location
B C	Southwest corner	Pipe insulation	6	Damage & debris	7	Maintenance access
A	Southeast pit	Pipe insulation	9	No visible damage	5	Maintenance access
I	Boiler #4	Steam drum insulation	9	No visible damage	5	Elevated location
L	North room	Tank insulation	9	No visible damage	3	Limited use of space

an overall assessment for the building or facility, and sorting the table according to CC and PFD places the most heavily damaged and accessible ACM at the top of the list. This allows one to prioritize the materials for abatement and O&M.

Of the functional spaces and homogeneous areas in Table 5, highest priority would go to the tank and fittings in the southwest corner due to their poor condition and high accessibility. At the bottom of the table, the tank insulation in the North Room, which is virtually intact and less accessible, can continue to be managed in place. By scanning this table the Asbestos Program Manager can see where to get the most value from his O&M and abatement budget, with somewhat more precision than if only the qualitative ratings had been used.

The quantitative assessments can be shown graphically with an Abatement vs O&M Decision Chart. Figure 58 is such a chart for the ACM in Table 5. The axes of the chart are Current Condition and Potential for Disturbance. Each type of ACM is identified by a letter corresponding to Table 5 at the intersection of the ratings for that material.

Figure 59 shows a line dividing the Decision Chart into an Abatement region (above the line) and an O&M region (below the line). The location and shape of the line is a reflection of the asbestos management program for the facility—whether it favors management in place or removal. In this example, the line is bent toward the upper left corner, indicating a bias toward management-in-place. Only the ACM in four locations—D, E, J and K—is designated for removal and J is a borderline situation. All other asbestos-containing materials will be managed in place through an O&M program.

Figure 60 shows a Decision Chart where an Asbestos Program Manager is more inclined toward abatement and will only leave the ACM in three locations—A, I and L—in place, removing the rest.

Drawing the Line. Sidebar 2. explains the thought processes behind dividing the chart into abatement and O&M regions on the basis of factors specific to a building or

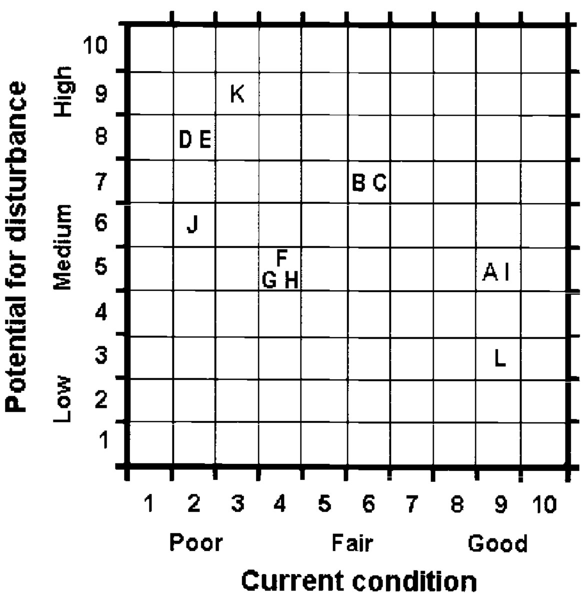

Fig. 58—Assessment ratings for boiler plant.

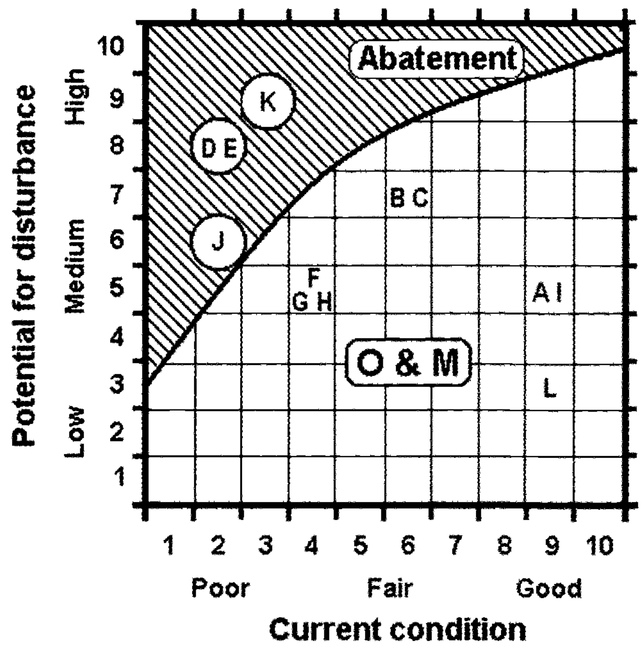

Fig. 59—Abatement vs. O&M Chart biased toward O&M.

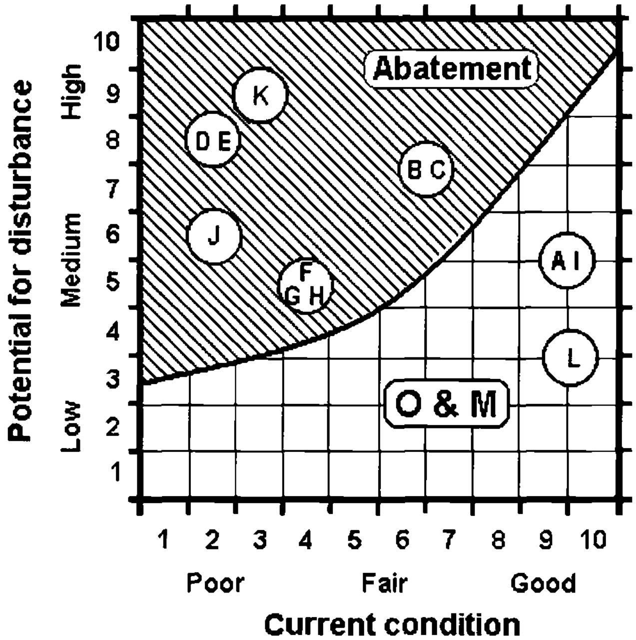

Fig. 60—Abatement vs. O&M Chart biased toward abatement.

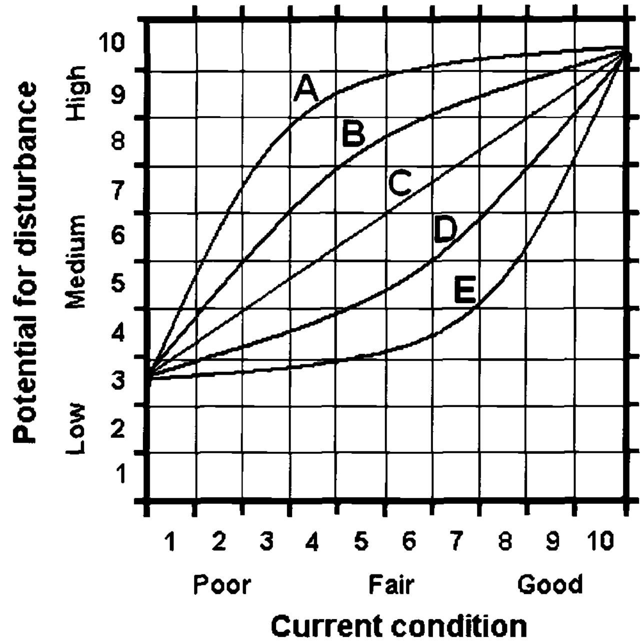

Fig. 61—Decision chart reflecting complexity and frequency of O&M tasks.

Sidebar 2—Drawing the Line

The simplest Abatement vs. O&M Decision Chart would have a straight line from the lower left corner to the upper right corner, creating equal-size Abatement and O&M regions, which would not be a realistic representation of most asbestos management programs. To properly divide the chart, we need to define the intercepts—where the line crosses the vertical axes—and its shape—how far it bends toward the upper left or lower right corners.

Defining the intercepts

The intercepts reflect the extent of damage and potential disturbance the Asbestos Program Manager is willing to tolerate. The higher the intercept on these axes, the greater the willingness and ability to conduct small repairs and clean up fiber release episodes, indicating a preference for O&M as a course of action.

If you are only willing to tolerate a very low disturbance of ACM in very poor condition, mark the intercept at PFD = 1 on the left axis. If you are willing to tolerate a low-to-medium potential for disturbance of ACM in this condition, mark the intercept at PFD = 2 or higher on this axis.

If you are willing to tolerate a very high potential for disturbance of ACM in very good condition, mark the intercept at PFD = 10 on the right axis. If you are only willing to tolerate a medium-to-high potential for disturbance of ACM in this condition, mark the intercept at PFD = 9 or lower on this axis.

Each of the straight lines that could be drawn with this approach reflects a different propensity to tolerate existing and future damage. Line C in Fig. 61 connects intercepts at PFD = 3 on the left axis and PFD = 10 on the right axis. This line biases decisions in favor of O&M by 60%—the area below the line. The abatement region above the line has 40% of the total area of the chart.

The higher the percentage of chart area "above the line" in the abatement region, the more the approach requires ACM to be abated on the basis of Current Condition and Potential for Disturbance. However, the risk of exposure would persist even with an O&M program in place. The fact that O&M programs entail some risks and costs of their own is taken into account by bending the line separating the abatement and O&M regions. Bending the line is a function of the complexity and frequency of the expected O&M tasks for the building or facility.

Bending the line

Complexity takes into account the difficulty of access to the ACM, the difficulty of preparation (such as de-energizing and cooling pressurized lines), disruption of operations, tight working conditions, hot or cold environments, type of PPE required and other factors in addition to the difficulty of the work itself. Frequency is simply the expectation of how often the O&M work will need to be done—for mechanical systems this may reflect the age of the equipment. Also, the more complex the O&M work and the more frequently it has to be done, the more likely that something might go wrong in the process.

Therefore, higher complexity and frequency suggest that abatement might be the more desirable solution for one or more reasons. The decision chart takes complexity and frequency of O&M work into account by bending the dividing line into the abatement or O&M region, or keeping it straight, once the intercepts on the vertical axes have been determined and connected with a straight line.

Line C in Fig. 61 is a straight line indicating that O&M tasks of ordinary complexity and frequency would be expected. Line B would reflect a situation where O&M tasks were anticipated to be less complex or less frequent, but not both, justifying a greater reliance on O&M and placing more of the area of the chart under the line in the O&M region. Line A would indicate that the O&M tasks could be expected to be both less complex and less frequent, placing even more of the area of the chart under the line in the O&M region.

The opposite situations are shown by bending Line C into the O&M region for tasks that are more complex or more frequent, but not both (Line D) and for tasks that are both more complex and more frequent (Line E). Bending the line in this manner places more area above the line in the abatement region, so that less ACM will be assessed in the region under the line and managed in place.

It is worth repeating that this assessment protocol, the tables and charts are tools to help the Asbestos Program Manager make informed decisions about abatement of ACM and managing it in place. These decisions are never as simple as plotting lines and sets of ratings, as they require the exercise of professional judgment and consideration of many factors specific to a building or facility. ◆

facility. It will help you visualize your decisions whether actually drawing the line on paper or just conjuring up a mental image of where it might be located. Bear in mind that the Decision Chart is merely a graphical tool for visualizing the relative priorities of abating ACM vs. managing them in place, and is meant to complement, rather than replace, your experience and judgment in making these decisions.

Reference

[1] Brown, S. K., "Physical Properties of Asbestos-Cement Roof Sheeting after Long-term Exposure," J Occu. Health Safety-Aust NZ Vol. 14(2), 1998, pp. 129–34.

4

Abatement Projects—Removal of Asbestos-Containing Materials

THE PROCESS OF ASSESSING THE CURRENT Condition and Potential for Disturbance of asbestos-containing materials as described in Chapter 3 often leads to a decision to undertake an asbestos abatement project. There are other reasons to abate ACM, which is usually done by removing it. The most common reason is compliance with the NESHAP regulation that effectively mandates abatement of any ACM that might be disturbed during renovation or demolition work. Abatement projects are also undertaken to reduce the building owner 's liability, as part of a financial transaction and for other reasons.

Whereas Chapters 2 and 3 focused on ASTM E 2356 Standard Practice for Comprehensive Building Asbestos Surveys, Chapters 4–6 explain the use of ASTM E 1368 Standard Practice for Visual Inspection of Asbestos Abatement Projects. The first edition of this *Manual* was subtitled "Removal, Management and the Visual Inspection Process." To dispel the notion that visual inspection is an activity limited to the conclusion of the project, ASTM E 1368 defines the *visual inspection process* as:

> "The activities before, during, and at the conclusion of a response action that are associated with detecting the presence of visible residue, dust and debris, or unremoved material and verifying the absence thereof at the completion of a response action."

It is appropriate to ask when the visual inspection process begins and also when the abatement project starts.

"Activities before" clearly include the Baseline Survey and Project Design Survey discussed in Chapter 2, as it is essential to know where the ACM is to have it removed. Thus the surveys lay the "foundation" for an abatement project, much as a building rests on its foundation.

When the abatement project starts is a matter of responsibilities. For the consultant, it could be said to start with preparing the plans and specifications, or even during the Project Design Survey, depending on how the contract with the building owner is written. It starts for the project monitor whenever he gets involved in these activities, and preferably no later than the Pre-Bid Conference. For the abatement contractor, the project starts upon award of the contract, with the Pre-Construction Meeting being the first time the crew mobilizes at the site.

Most abatement projects are performed under contractual arrangements involving the building owner, consultant and/or project monitor, and abatement contractor. The role of the consultant in performing a Comprehensive Building Asbestos Survey was discussed in Chapter 2, and this chapter expands his role to include acting as the owner 's representative for an abatement project. The role of the project monitor (see ***The Project Monitor***, Sidebar 1.) who may be the same individual as the consultant, is specific to the abatement project. When we speak of the abatement contractor, it means the firm unless the context mentions the abatement contractor 's supervisor. See ***Contractual Relationships and Responsibilities*** Sidebar 2. on contractual relationships and how to make them work most effectively.

The remainder of this chapter, and all of Chapter 5, will focus on the roles of the building owner, asbestos consultant/project monitor and abatement contractor. This is not intended to slight the contributions of the architect or engineer and the general contractor when renovation is involved, and their participation will be noted when appropriate.

The emphasis in this chapter is on the type of work that OSHA defines as Class I, although that term is not used in ASTM E 1368. Class I work is removal of surfacing materials as represented by fireproofing and acoustical plaster, and thermal systems insulation, typified by pipe, boiler, and duct insulation. These materials comprise the majority of friable ACM, removal of which is typically performed in connection with renovation or demolition. This is the most complex and expensive type of response action undertaken, and the type most fraught with potential for contamination and liability if something goes wrong. In the world of response actions, this is the big leagues, and the term often used to describe it is *gross removal*. Not to minimize their importance, we will deal with miscellaneous materials and other abatement methodologies in the next chapter.

Abatement Project Design

Anyone who prepares an asbestos abatement project design must be accredited as a project designer and must also be licensed in some states. Training courses for project designers assume a background in architecture, engineering, or some other aspect of the construction field.[1] For those whose experience is not strong in these disciplines, a text on building characteristics is recommended [1].

[1] Academic programs for industrial hygienists could benefit from the addition of instructional material on building construction and operations, considering all of the environmental concerns (asbestos included) affecting buildings. For example, industrial hygiene courses cover the design of ventilation systems for manufacturing operations, but not HVAC systems for offices and other conditioned spaces in buildings.

Sidebar 1—The Project Monitor

ASTM E 1368 borrows the definition of *project monitor* from the EPA Model Accreditation Plan:

> "The building owner's representative who observes abatement activities performed by contractors to ensure that abatement work is completed according to specifications and in compliance with all relevant statutes and regulations."

This broad definition encompasses all of the duties of the project monitor, including air sampling and overall surveillance of the work as well as conducting the visual inspections.

Qualifications of the project monitor are stated in Section 6 of ASTM E 1368. This person needs to know where asbestos is found in buildings and how it is supposed to be removed. ASTM E 1368 asks for credentials that indicate knowledge of building design, construction and operations, familiarity or expertise in asbestos abatement and O&M techniques, and familiarity or expertise with suspected ACM and its substrates. These credentials can be based on a combination of academic degrees, specialized training such as the AHERA courses, and experience in asbestos work or related fields.

EPA does not consider the project monitor to be conducting the response action—the abatement contractor does that—so the project monitor need not be accredited as an abatement supervisor or worker. The project monitor is not required by AHERA or ASHARA to be accredited as an inspector in order to conduct visual inspections for completion of response actions. In the definition of Inspection, one of the three activities listed in the Model Accreditation Plan for which accreditation is not required is "c. Visual inspections . . . solely for the purpose of determining . . . completion of response actions."

Some states license project monitors, although they may call them something else. In Illinois and Texas, they are called project managers; New Jersey calls them Asbestos Safety Technicians. Often, the air monitoring aspects of the project monitor's job is stressed in these regulations, and the connection between a clean site and clean air needs to be appreciated. However, neither NIOSH 582 nor any other air-monitoring course (that I am aware of) provides enough information on visual inspection, building characteristics, abatement procedures, or the other things that project monitors need to know to fulfill their responsibilities under ASTM E 1368. The ASTM Standards for Asbestos Control course provides a thorough grounding in these fundamentals. The "Understanding Building Systems" and "Uses of Asbestos" lectures in the AHERA Building Inspector course also provides a good foundation for this work, and completion of a course for abatement contractor supervisors, or its equivalent, is also beneficial. If the project monitor also participates in the Project Design Survey, or take bulk samples during the project, the qualifications of an accredited inspector as described in Chapter 2 apply.

ASTM E 1368 recognizes the physically demanding aspects of the project monitor's job, which can be nearly as rigorous as that of the abatement workers and supervisor. Visual acuity is important, because visual inspections are done with two of the most sensitive instruments at the project monitor's disposal: his own eyes.

One of the most important qualifications for the project monitor is knowing how to act at a construction site and, in particular, an abatement site. As the owner's representative who interprets and enforces the contract documents, the project monitor needs experience in monitoring the work—not just the air—at abatement projects. Most of the difficulties, delays, and litigation that arise from abatement projects have more to do with basic construction management problems than with asbestos or air samples. An "apprenticeship" under a "mentor" with experience in the field is advised before taking on full responsibility for monitoring a project. ◆

ASTM E 1368 charges the abatement contractor to remove the asbestos and clean the work site *in accordance with the contract documents*. The operative words are stressed: the contractor's responsibility extends no further. How well that responsibility is defined for any given project depends on the thoroughness of the building survey and the project design.

Abatement Drawings

The Project Design Survey was covered extensively in Chapter 2, and it is time to see how that information is translated into the plans and specifications. It does not suffice to simply put a copy of the drawings from the survey report in the bid package for the abatement project.

The bid package should include drawings of sufficient number, size and detail to convey to the contractor the information needed to remove ACM as intended by the project designer. These may vary from a single-sheet marked-up floor plan to a set of full-size Auto-CAD™ drawings. Before committing to the preparation of abatement drawings, find out how they will be reproduced and distributed. Will they be reproduced on paper or the files put on a CD? What format does the building owner need the files in? Can enhancements such as color and photographs be used on the abatement drawings?

The ASTM *Standards for Asbestos Control* courses include workshop exercises to illustrate some of the challenges of asbestos abatement. Figure 64 is a section through a fictitious building used in one of these exercises that assumes abatement will take place in phases on all levels of the building. The exercise got the class "thinking vertically" about asbestos abatement in a multi-story building. The value of a detailed abatement drawing is not only that it allows the project designer to convey instructions to the abatement contractor, but also that it forces the project designer to confront and resolve such issues as this figure illustrates:

- How will the duct be removed from the masonry block chase?
- How will ventilation be maintained to floors other than the one undergoing abatement?
- How will the pipe insulation in the chase be removed?
- If the perimeter-heating units were being removed, how would the ones on the first floor be disconnected from the pipes in the crawl space—an area that may be contaminated?
- Which floor should be abated first?

Chapter 2 contained an example of a project (Figs. 28–30) where problems arose because of vague requirements in the abatement drawings. A few more examples show how

Sidebar 2—Contractual Relationships and Responsibilities

A multitude of contractual relationships exists for performing asbestos abatement projects. For example, consultants regularly retain one another for assistance on projects. Also, building owners often conduct their own visual inspections, and may even conduct the abatement with their own personnel. Regardless of these relationships, it is important to establish and maintain the independence of the consultant and project monitor from the party doing the actual abatement work—the abatement contractor.

The responsibilities of the principal participants—the building owner, the owner's representative(s) and the abatement contractor—are discussed in Section 7 of ASTM E 1368. For an abatement project, the building owner (or, if applicable, a tenant or the property manager) usually contracts with the abatement contractor for the performance of the work: removal, encapsulation, or enclosure of the ACM. The building owner enters into a separate contract with another individual (or company), generally as a consultant, who acts as the building owner's representative. This latter individual or company is *contractually responsible to the building owner, not to the abatement contractor*. The contractual relationships of these participants are shown in Fig. 62 for a project limited to asbestos abatement.

However, asbestos abatement rarely takes place for its own sake. It usually precedes a renovation or demolition of a building, primarily to satisfy requirements in the asbestos NESHAP or state or local regulations. The building owner may also decide that a convenient and cost-effective opportunity exists to remove the asbestos while the premises are vacated for reasons other than renovation. The abatement contractor and the project monitor (or, in some cases, the consultant or other entity to whom the project monitor reports) effectively hand the renovation contractor and architect a building in which asbestos has been abated to the extent specified in the contract documents. This is done under contracts that must clearly separate the abatement project from other work at the site, as shown in Fig. 63, which includes the general contractor and architect or engineer responsible for related renovation work as well as the abatement contractor and asbestos consultant/project monitor.

The building owner has the option of contracting directly with the asbestos consultant and abatement contractor or dealing with them through sub-contracts from the architect or engineer and general contractor. The advantages and disadvantages to both approaches become evident when considering the principal contractual responsibilities shown in Table 6. These responsibilities are for an abatement project preceding renovation or demolition.

The responsibility of the building owner can be stated generally as selecting competent firms and people (the word "hire" is used in Table 6 in a contractual sense, not in the context of employment) and clearly specifying the work they are supposed to do, as in any construction project. A building owner who contracts directly with all four participants must manage four contracts, whereas this burden is halved if the general contractor and architect or engineer hire the abatement contractor and asbestos consultant, respectively. Shifting the burden of contract management to another party, however, lessens the degree of direct control that the building owner has over the work.

The architect's or engineer's job is to design and manage the renovation, and in the process provide the asbestos consultant with drawings for designing the abatement project. The architect or engineer is not responsible for any abatement-related work unless directed by the building owner to manage the asbestos consultant through a sub-contract. In this case, the asbestos consultant answers contractually to the building owner through the architect or engineer, not through the general contractor.

The general contractor is primarily responsible for the renovation, but is sometimes interposed between the building owner and the abatement contractor, with the latter being hired as a subcontractor. Although such arrangements are distasteful to many general contractors, because of the liability and insurance implications of asbestos, they are often forced to accept them on publicly bid projects. OSHA asbestos regulations for the construction industry [29CFR1926.1101(d)(5)] place compliance responsibilities for abatement work performed under subcontract on the general contractor:

> "All general contractors on a construction project which includes work covered by this standard shall be deemed to exercise general supervisory authority over the work covered by this standard, even though the general contractor is not qualified to serve as the asbestos "competent person" as defined by paragraph (b) of this section. As supervisor of the entire project, the general contractor shall ascertain whether the asbestos contractor is in compliance with this standard, and shall require such contractor to come into compliance with this standard when necessary."

It is in the general contractor's best interests to demand the highest standards of work by the abatement contractor. This may be difficult when the renovation and abatement contracts are awarded to the low bidders.

Sub-contract arrangements do not alter the responsibilities of the building owner, abatement contractor, and project monitor as discussed herein, nor should they compromise the independence of the project monitor in performing his work. To the contrary, the intervening general contractor and architect or engineer takes on a responsibility to support the efforts of the other parties in fulfilling the requirements of the subcontracts. This includes scheduling a Pre-Bid Conference for prospective bidders on the abatement subcontract to view the work and become familiar with the requirements. Regardless of the contractual framework, the pressures of cost and schedule affecting the subsequent renovation or demolition project should not be used as an excuse to compromise the quality of the abatement work.

The abatement contractor's responsibilities do not depend on who has contracted for his services and pays the invoices. The advantage of a direct contract with the building owner is the access it provides in event of a project management or payment issue and the equal status the abatement contractor enjoys with the general contractor. The abatement contractor's job is to remove the asbestos, clean the work site and dispose of the asbestos waste. The contractor's competent person is expected to assist the project monitor during the visual inspections.

The asbestos consultant's responsibilities, like the abatement contractor's, do not depend on who has contracted for his services. The advantages of direct access to the building owner in event of a project management or payment issue, and the equal status the asbestos consultant enjoys with the architect or engineer and the general contractor, are significant. ◆

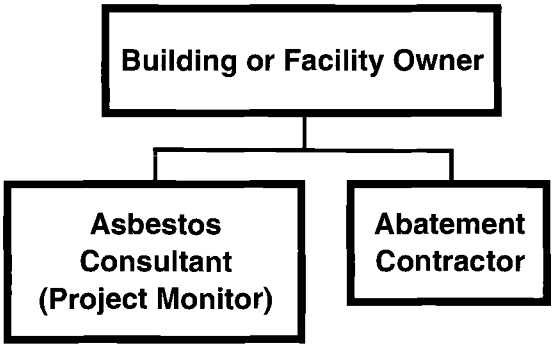

Fig. 62—Basic contractual relationships for abatement project.

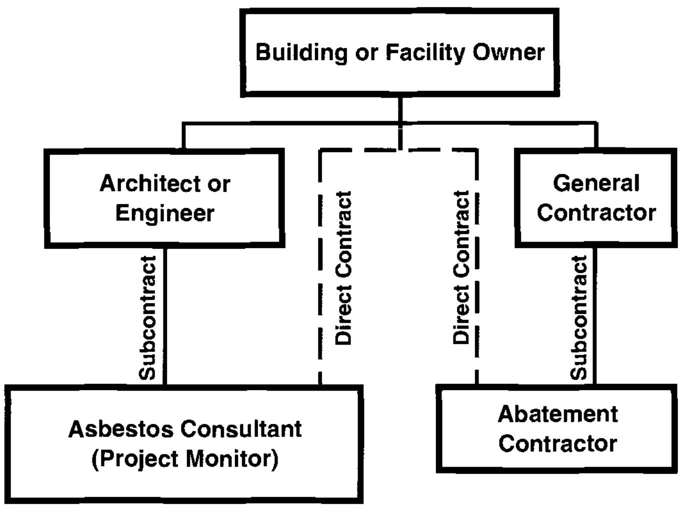

Fig. 63—Contractual relationships for abatement preceding renovation.

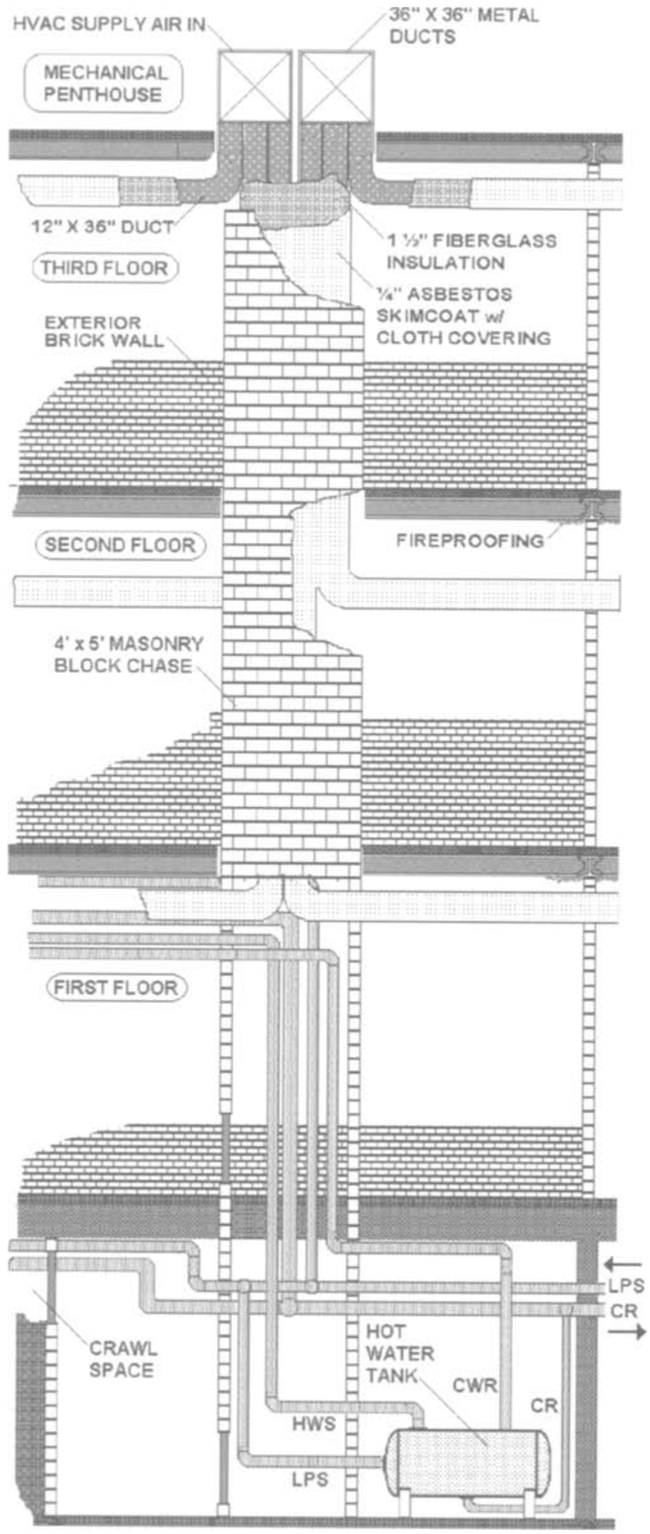

Fig. 64—Multi-story building abatement problem.

the project designer can avoid such problems through careful preparation of the plans.

- In Fig. 65, the perimeter beams are boxed in with a soffit. If the job includes removal of the fireproofing inside the soffit, this should be indicated on the drawing. If the fireproofing is not to be removed, a note on the drawing "ACM inside soffit to remain" would take care of it.
- The plenum above the ceiling in Fig. 66 has asbestos fireproofing. The drawings should indicate whether removal of the fireproofing or a plaster ceiling, insulated pipes or ducts, or other ACM—is within the scope of the project. Any such material not within the scope of work should be identified on the drawings. If the tiles are glued to the deck as opposed to being attached to splines, indicate whether the mastic contains asbestos and if its removal is part of the project.
- If the top of an interior wall is in direct contact with asbestos fireproofing on the deck or with an asbestos-containing plaster ceiling, demolishing the wall will release debris from the fireproofing or plaster. It would be preferable for the abatement contractor to demolish the wall instead of the general contractor, and this should be shown on the drawing.
- The beam in Fig. 67 was too close to the metal wall to be able to reach in and scrape off the fireproofing. These beams were well above floor level and not accessible to building occupants. The drawings contained notes: "Overspray on corrugated metal wall to be removed"

Table 6—Responsibilities of renovation and abatement project participants.

Project Participant	Direct Contract	Sub-contract
Building Owner	Define scope of work for contracts Hire, manage & pay • Architect or Engineer • General Contractor • Abatement Contractor • Asbestos Consultant	Define scope of work for contracts Hire, manage & pay • Architect or Engineer • General Contractor
Architect or Engineer	Design and manage renovation Provide renovation drawings Coordinate project schedules	Design and manage renovation Provide renovation drawings Coordinate project schedules Define scope of work for consultant contract Hire, manage & pay Asbestos Consultant
General Contractor	Perform renovation Coordinate project schedules	Perform renovation Coordinate project schedules Define scope of work for abatement contract Hire, manage & pay Abatement Contractor
Abatement Contractor	Prepare work areas Perform removal and clean-up Assist during visual inspections Dispose of asbestos waste material	
Asbestos Consultant	Attend Pre-Bid Conference and Pre-Construction Meeting Provide project monitor services including air monitoring for owner Perform visual inspections for preparation, removal and clean-up Certify completion of abatement work	

Fig. 65—Soffit enclosing fireproofed beam.

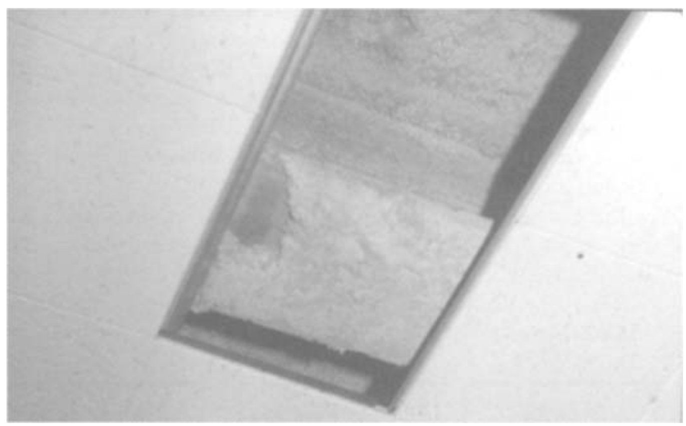

Fig. 66—Fireproofed beam and deck above splined ceiling tiles.

and "Unremovable fireproofing behind beam to be encapsulated per spec." Thus the contractor was required to remove all of the fireproofing within reach and cover the rest with a penetrating encapsulant. We will come back to this situation in Chapter 5.

Abatement Specifications

There are a number of "boilerplate" specifications available, including the National Institute of Building Sciences *Asbestos Abatement and Management in Buildings: Model Guide Specification* [2] and the master specifications of several government agencies. Most consulting firms have their own proprietary abatement specifications and whether to use them or the client's should be decided when negotiating the contract for consulting services.[2]

A detailed discussion of the contents of abatement specifications is beyond the scope of this *Manual*, and reference to the materials used in project designer training courses is advised. Two mistakes to avoid when preparing a specification:

[2] Specifications are the property of the individual or firm that prepared them, and using them for one project does not give the building owner, or anyone else, the right to use them on other projects without permission. It is worth stating this explicitly on the cover page of the specification.

Fig. 67—Fireproofing between metal wall and beam.

- Incorporating provisions of a "boilerplate" or "master" specification that do not apply to the work to be performed or, worse, that conflict with the intent of the project designer. Careful reading and editing of the entire specification is necessary to avoid this problem.
- Referencing another document without fully understanding the consequences. Page 68 discusses an example of referencing the AHERA regulations for final air sampling that resulted in litigation because the contractor and consultant differed on their interpretations.

It is important to note here that the paragraphs specifically describing the visual inspection process must be consistent with the remainder of the specification. It does no good to say in one part of the specification that there will be one final visual inspection before air samples are taken and then discuss elsewhere the ASTM E 1368 approach of two visual inspections for completeness of removal and completeness of clean-up. One important addition to any specification is the flow chart in Fig. 68 that illustrates the visual inspection process. This chart shows the sequence of activities that we will discuss in the remainder of this chapter. The specification should include a detailed, step-by-step explanation of this sequence, tailored to the particular site and project. Project designers may copy the flow chart and incorporate it in their specifications, providing that credit is given to ASTM and this *Manual* as the source.

ASTM E 1368 emphasizes that its provisions are not intended to supersede or negate those of any contractual document between the parties involved in an abatement project. On the contrary, if the scope of work is properly written, they are quite compatible. However, situations may exist where state regulations or a master specification may require deviating slightly from the sequence shown in the chart. (See **Inspections at the Conclusion of the Project**.)

The abatement specification should not mention replacement materials. As the building owner 's representative, the consultant is responsible for certifying that the ACM has been removed according to the contract documents and the area can be renovated for re-occupancy. Renovation will include replacement of fireproofing, mechanical insulation and finishes to bring the area back into compliance with codes before it can be re-occupied, and this is the responsibility of the architect, engineer and general contractor—not the asbestos consultant or abatement contractor. Furthermore, the specification and inspection of replacement materials in some jurisdictions requires professional licenses that most asbestos consultants do not maintain.

Bid Solicitation

There is more to a bid package than the plans and specifications. The building owner may want the consultant to prepare the actual contract that the abatement contractor will execute, as well as the documents to solicit the bids. The elements of a typical bid package are described in ***The Bid Package*** (Sidebar 3). An important part of the bid solicitation process is the Pre-Bid Conference, described next.

The Pre-Bid Conference

The consultant should conduct, and the project monitor should participate in, the Pre-Bid Conference, at which abatement contractors can inspect the site before submitting their bids for the work. Letting the prospective bidders ask questions in a forum where everyone can hear the answers levels the playing field for all contractors. Situations where

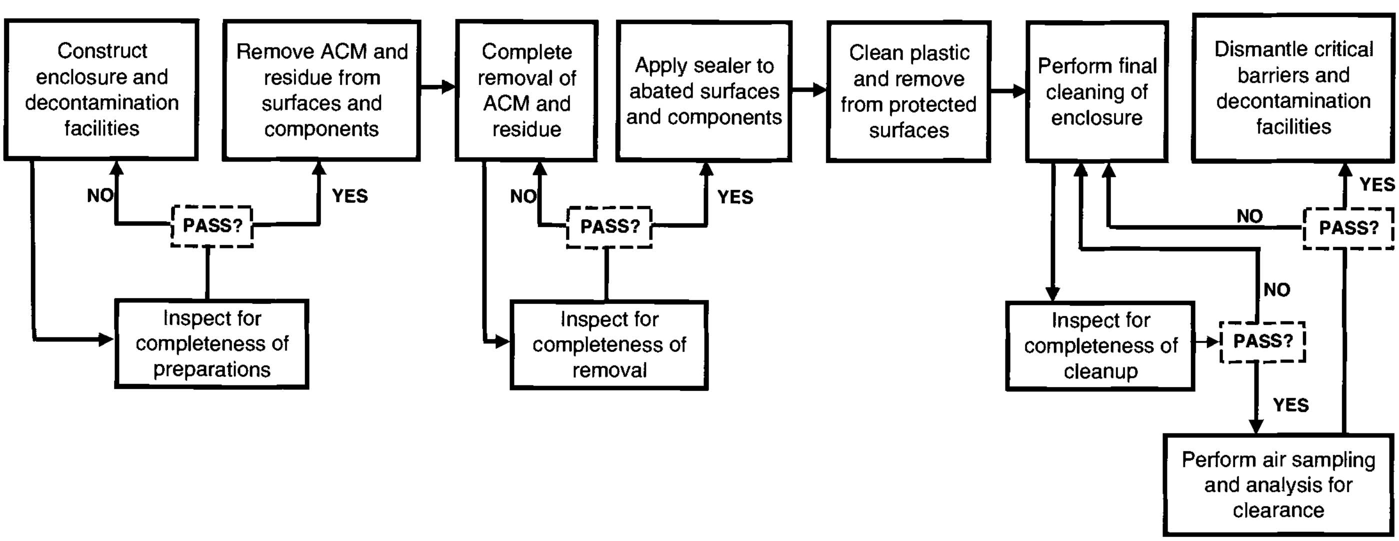

Fig. 68—Visual inspection activities for abatement project.

Sidebar 3—The Bid Package

The set of documents sent out to prospective offerors is commonly called a bid package and contains the following sections.

Invitation to Bid—A cover page including the time and place of the Pre-Bid Conference and the deadline for submitting proposals. This is followed by detailed instructions on how to prepare and submit the offer. Indicate to whom the proposals must be submitted and require that the building owner receive the original before the deadline, with a copy to the consultant.

Proposal for the Contract—The cover page re-states the submittal deadline, and the detailed instructions that follow ask the bidder to acknowledge all addenda and state the amount of the offer. Provide a place for the pricing of alternates, such as excluding certain items from the scope of work.

As an attachment to this section, provide a Statement of Qualifications form for the bidder to complete. Discourage submittal of company brochures in lieu of this form and emphasize that completion of the form is necessary for consideration of a bid.

This form asks for the information that many specifications request in a section on Qualifications, but the time to submit that information is with the proposal, not after the contract is awarded. The form requests details on the qualifications of the contractor, including recent projects of comparable size and client references.[1] The form asks for the qualifications of the bidder's personnel, especially the supervisor who will direct the work. Ask the bidder to acknowledge that the supervisor is a competent person as defined in the OSHA construction industry standard. Training certificates and licenses should be submitted for enough workers to show that the contractor has adequate manpower for the job. Check to see that the training certificates and licenses don't expire before the project is expected to be finished.

Due to privacy and identity theft concerns, ask the bidders not to include copies of medical examination results or other information with a worker's Social Security Number. Unfortunately, the SSN is still used on some state licenses and training certificates. If such documents are received as part of a bid, it would be prudent to make copies with the SSN obliterated and return the originals to the bidder.

Specifications and Drawings—Sometimes called the Project Manual, the specifications describe in detail the scope of work and all other requirements that the abatement contractor must comply with. These requirements may be made part of the specification by referencing other documents in which they appear.

The drawings should be prepared for the abatement project and not just be copies of the drawings from the Baseline Survey. They should incorporate all of the information from the Project Design Survey that can be effectively conveyed in a drawing format.

Abbreviated Form of Contract—This is the "boilerplate" construction contract with a few modifications for abatement work. The contract that goes into the bid package has blanks for the contractor's name and the contract amount, to be filled in after the contract is awarded, and signature blocks for both parties. This section will be lengthy, and some government contracts for abatement projects are over an inch thick. The price for preparing, copying and distributing such extensive documentation should reflect the considerable amount of work involved.

Health and Safety Certifications—Clients with very strict safety policies may require that copies of these policies and qualification forms be included in the bid packages so their staff can review the responses for compliance by the bidders with their safety requirements. ◆

[1] The responses of former clients have ranged from glowing praise to carefully hedged answers. Asked if they would use the contractor again, one reference—a public agency—said "If they submitted the low bid, we would have to." With that ringing endorsement, my client agreed to move on to the next lowest bidder.

removal and inspection are unusually difficult should be discussed, such as the air duct in Fig. 69. Clearance between the top of the duct and the ceiling was about half an inch, which was barely enough to determine that the ACM did not extend into this space. However, debris from scraping the ceiling was sure to get into this space. After discussing it during the Pre-Bid Conference, it was decided to leave the duct in place and mark it for special attention during cleaning, visual inspection, and aggressive air sampling.

Fig. 69—Air duct close to ceiling makes cleaning and inspection difficult.

Questions raised at the Pre-Bid Conference are better addressed through an addendum prior to the bid submittals than with change orders after the contract is let. The worst time to confront them is during the visual inspections at the conclusion of the project under pressure to complete the job. For the project monitor, as the owner's representative, it is extremely embarrassing to have additional ACM called to his attention as abatement—or worse, post-clearance renovation—proceeds. Slightly less so is the prospect of contractors attending the Pre-Bid Conference and pointing out such potential situations that might have been overlooked in the project design. Remember, some of those contractors have been around for a while and they may know the building as well (or better) than the project designer who prepared the plans and specifications.

The Pre-Bid Conference is also a good time to set the tone for the project regarding the expectations to pass the visual inspections. ASTM E 1368 is used most effectively if the project monitor's authority as the building owner's representative is clearly delineated and understood by all participants. Because ASTM E 1368 is a qualitative standard, there are no numerical "pass-fail" criteria as there are in air monitoring. This also means that the project monitor's evaluations will be, to some extent, subjective, and whether an area passes or not depends on his judgment as a reasonable professional. Some project monitors are harder to please than others, and an abatement contractor's decision to bid or not may be

influenced by knowledge of who will do the visual inspections. If the abatement contractor declines to bid on the basis of that knowledge, it may turn out to be better for all concerned.

It is unfortunate that many publicly bid abatement projects do not require a prior site visit as a condition of submitting a bid. As a result, the successful contractor often finds more asbestos than he bargained for, or other conditions that make the job more difficult and wipe out the anticipated profit. The situation is exacerbated if the building survey and project design were inadequate and did not clearly define the building owner's expectations in the scope of work. The result is a confrontation over how much asbestos the contractor is obligated to remove, resulting in delays, acrimony, and, often, litigation.

During the Project

After the contract is awarded, the consultant schedules and conducts the Pre-Construction Meeting, which is usually the successful contractor's first look at the site since the Pre-Bid Conference. The project monitor should use the Pre-Construction Meeting to reinforce the tone set at the Pre-Bid Conference regarding expectations for the work to pass visual inspection, as well as for the preparation and abatement activities preceding the inspections. This may be the first time that the contractor's supervisor sees the job site, but he should have reviewed the specification and drawings before the Pre-Construction Meeting.

Differing Site Conditions

There is often a substantial delay between the submittal of bids and the contract award, or the contract award and the actual start of abatement. Delays of more than a year are not uncommon, particularly where abatement is part of a complex, phased renovation project in a large facility. During this time, things happen to the building and the ACM. Demolition and removal of interior walls and fixtures may occur, not always by those who know (or care) what asbestos looks like or how to handle it. A vacated area may be scavenged by maintenance workers, for example, and while they do not mean to knock the insulation off the water pipes when they remove the plumbing fixtures, it happens anyway. The electrician thinks he is being helpful by removing the light fixtures from the ceiling, and knocks a lot of plaster loose in the process (Fig. 70). Vacant buildings are sometimes vandalized in the interim (Fig. 71). The abatement contractor and project monitor subsequently find debris and asbestos contamination in a room that was clean and orderly during the Pre-Bid Conference. This is called Differing Site Conditions in the contract documents, which should specify that compensation and schedule relief are due the contractor for the additional effort to remedy such situations. The time to address the matter is at the Pre-Construction Meeting.

Inspection During Area Preparation

The project monitor is required to visit the job site regularly to maintain continual cognizance over the progress of the work and to address problems as they arise. The intent of ASTM E 1368 is to maintain the work site as clean as possible on a continuing basis, rather than depend on an intensive last-minute cleanup effort when the temptation exists for schedule pressure and cost considerations to compromise standards of performance.

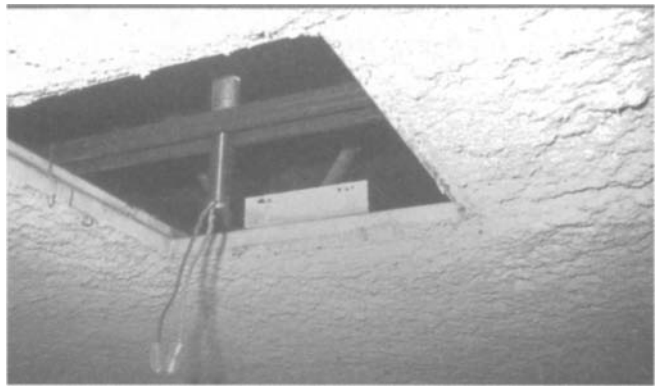

Fig. 70—Light fixture removed from asbestos plaster ceiling by electrician.

Fig. 71—Sink torn off wall by vandals in vacant building.

Some state regulatory agencies perform visual inspections at various stages of the project, such as when area preparations are complete, before final air samples are taken and after the critical barriers and decontamination facilities are dismantled. Usually, these agencies have the right to enter the work area at will for enforcement purposes, as EPA and OSHA also do. Of course, their inspections are not conducted according to the contractual documents, but according to the regulations of their respective agencies. As noted earlier, visual inspection procedures in state regulations are usually consistent with ASTM E 1368, which may even be specifically referenced. The project personnel and regulatory agency field staff have a responsibility to understand each other's inspection procedures and criteria. If all parties adhere to the concepts of ASTM E 1368 as elaborated upon in this *Manual*, there should be few surprises for anyone.

The project monitor begins surveillance of the contractor's work during preparation of the removal area. The project designer should have become familiar enough with the building to anticipate which parts of it are unusually susceptible to contamination and specified appropriate protective measures. The project monitor is supposed to verify that the contractor has carried out these measures. This is a critical time for the project monitor to be at the site, full-time if necessary, as some of the measures specified may be covered

up by subsequent preparation. The contractor does not appreciate having to tear up plastic to prove that something underneath is protected, or being asked to protect something that could have been dealt with earlier.

During area preparation, the contractor builds an enclosure that prevents contamination of the building from two sources: airborne fibers and contaminated water. Therefore, asbestos contamination is prevented by controlling the media that carry the fibers and debris.

"Critical barriers" are so called because breaching them could carry airborne fibers or contaminated water into adjacent spaces accessible to unprotected individuals. They are defined in ASTM E 1368 as follows:

> "One or more layers of rigidly-supported plastic sheeting sealed over all openings into an asbestos work area (with the exception of make-up air provisions and means of entry and exit), designed to prevent airborne asbestos fibers or asbestos-contaminated water from migrating to an adjacent area."

For the type and scope of project we are considering here, OSHA regulations for Class I work effectively mandate critical barriers to isolate the regulated areas in which the abatement takes place. To preclude the escape of airborne fibers, the project monitor carefully examines all rigid and flexible barriers across hallways and doors, between the tops of interior walls and the deck, over windows, grille vents and other openings between the removal area and adjacent spaces, including outdoors. A critical barrier across a hallway may consist of the doors themselves, sealed shut and covered with plastic, a temporary wall of studs and plywood or wallboard, or two layers of 6-mil (0.15 mm) plastic on both sides of a stud framework. On some larger projects, temporary structures of considerable size may have to be constructed to form parts of the enclosure and critical barriers (Figs. 72–74).

To prevent the escape of airborne fibers, the project monitor verifies that seams are sealed with spray adhesive and tape, edges are caulked, and all penetrations are sealed. To prevent water from running underneath the barrier and carrying asbestos debris out of the enclosure, the bottom edge should be caulked.

Fig. 72—Powered man-lifts used inside large enclosure.

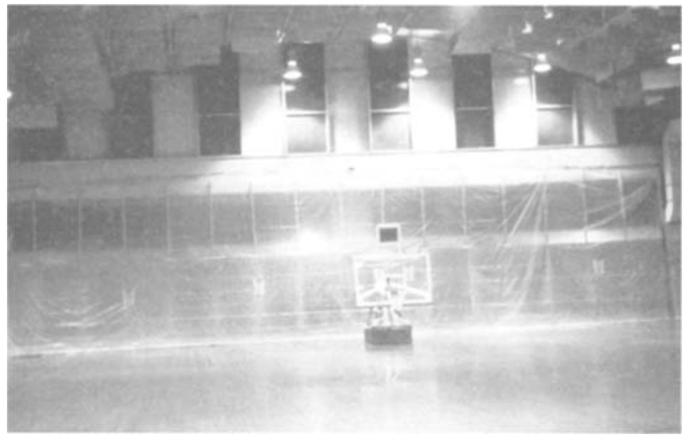

Fig. 73—Critical barrier of plywood and plastic across gymnasium.

This is a time to pay attention to details. While the critical barrier is being erected, imagine the plastic coming loose at the top and try to figure out where water that got behind the plastic would go. If the water ran down the barrier, could it leak through a seam and penetrate to the other side? Could water leak under the barrier if it ran down to the floor? Are there horizontal seams and edges that could

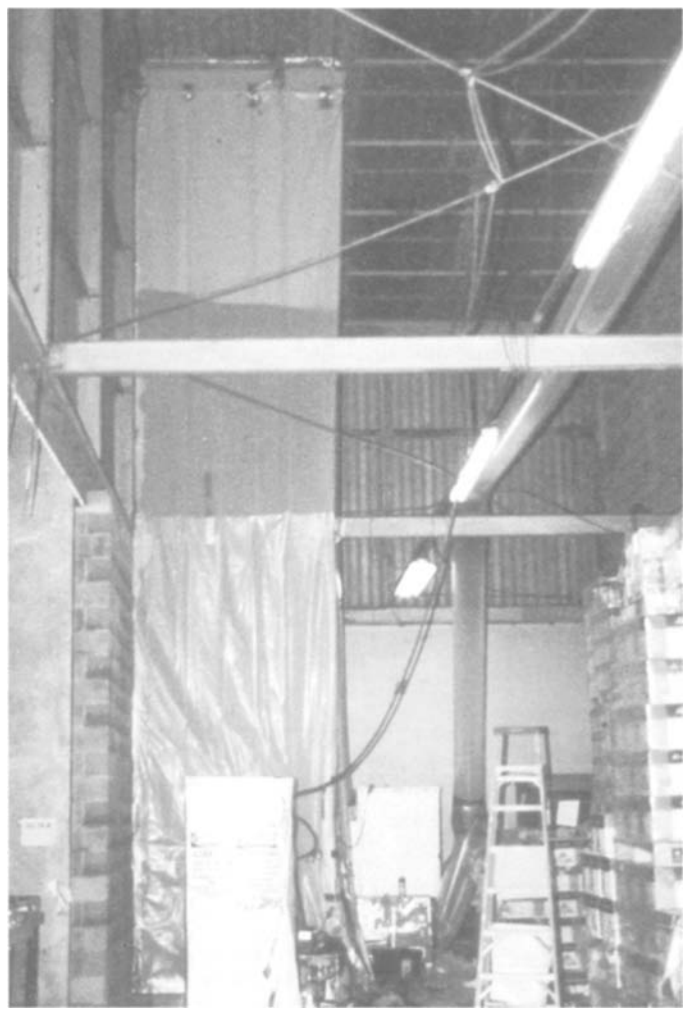

Fig. 74—Enclosure for abating fireproofed column.

trap water, allowing it to loosen the adhesive on duct tape or to seep through caulking? If there is a chance water could find cracks and seams to leak through and carry debris to the side of the barrier in the occupied area of the building, the barrier should be modified to eliminate those leak paths.

Critical barriers serve another purpose besides separating the removal area from occupied spaces in the building. Critical barriers over windows, doors, and other penetrations in the building envelope affect the integrity of the enclosure itself. To appreciate this we need to understand the operation of a negative pressure enclosure.

Figure 75 shows a large negative pressure enclosure with its "negative air machines" as we dubbed them in Chapter 2. Figure 76 is a schematic illustration of a negative pressure enclosure with a ceiling scrape in progress. The negative air machine in the foreground exhausts air through a HEPA-filter [3] and out the window, with "make-up air" coming through the airlock on the rear wall.[3] This places the air inside the enclosure (P_1) at a negative pressure relative to the outside air (P_0). This pressure differential must be at least 0.02 inches (0.5 mm) of water according to OSHA regulations and the air must be exchanged at least four times per hour. Many negative pressure enclosures operate at higher pressure differentials and more air changes per hour, but increasing one parameter doesn't necessarily result in a corresponding increase in the other.

Fig. 75—Negative air machines installed in critical barrier.

The project monitor should determine the number of negative air machines needed for each enclosure. The calculations are not rocket science—let's do the math for the enclosure shown in Fig. 75.

Determine the volume of the enclosure—This enclosure was 30 ft (9.1 m) wide and 85 ft (25.9 m) long with an average height of 29 ft (8.8 m). The volume was therefore

$$V = (30)(85)(29) = 73{,}950 \text{ ft}^3 \ (2094 \text{ m}^3)$$

Determine the required airflow—This depends on the above volume and also the exchange rate, n, expressed as the number of air changes per hour. For this project, the specification required four air changes per hour, so the required airflow Q_r was

$$Q_r = nV/60 = (4)(73{,}950)/60 = 4{,}930 \text{ ft}^3/\text{min} \ (139.6 \text{ m}^3/\text{min})$$

Determine the capacity of the negative air machines—The machines have nominal ratings expressed in ft³/min, or cfm. In practice, they deliver a fraction of their rated capacity, because airflow through them decreases as the HEPA-filters and the pre-filters load up and the fan wears out with use. For this enclosure, the machines were rated at 2,000 cfm each but Q_p = 1,500 ft³/min (42.5 m³/min) was used for the calculations.[4]

Compare the airflow provided by each machine (Q_p) to the total required for the enclosure (Q_r). If each machine provides 1,500 ft³/min (42.5 m³/min), three of them will provide 4,500 ft³/min (127 m³/min), which isn't quite enough. Four would be required, and having an extra one installed in case a machine stops working should be required by the specification.

Figure 77 shows the same schematic enclosure with air leaking through a broken window: (A) on the other wall. The air leaks could just as easily be through the window frame;

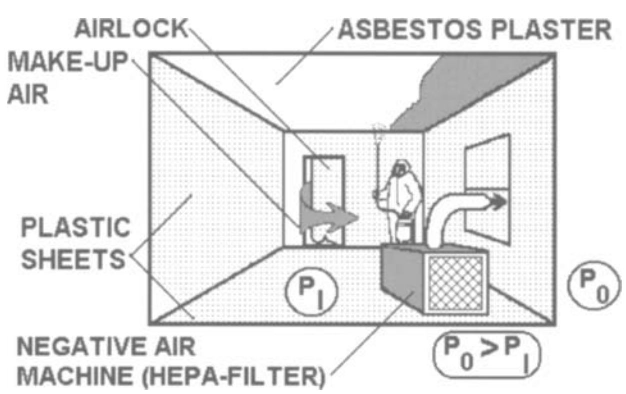

Fig. 76—Schematic illustration of negative pressure enclosure.

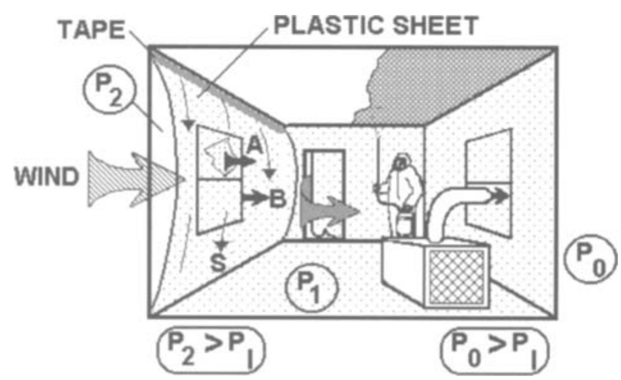

Fig. 77—Effect of wind infiltration on negative pressure enclosure.

[3] The correct definition of HEPA is High Efficiency Particulate Air, not Absolute or other common permutations. The referenced DOE standard defines a HEPA filter as follows: "A throwaway, extended-media, dry type filter with a rigid casing enclosing the full depth of the pleats. The filter shall exhibit a minimum efficiency of 99.97% when tested at an aerosol of 0.3 µm diameter." The efficiency actually increases for particles larger and smaller than this diameter. Of course, the filters are not tested against asbestos fibers and the rating applies to the filter, not the negative air machine as an assembled unit.

[4] The actual flow rate through each machine can be determined by measuring the average velocity of the air entering the filters with a velometer and multiplying by the filter area.

(B) or other penetrations in the wall. Air *infiltration* results when the wind blows against the side of the building and if the air leaks into the space between the wall and the plastic sheets, it creates a pressure (P_2) that is greater than the pressure in the enclosure. The pressure differential causes the plastic sheets inside the removal area to balloon and pull loose from the wall.

Figure 78 shows the effect of a broken window at a boiler plant on the large sheet of plastic covering the wall inside. In extreme cases (Fig. 79), the floor plastic also balloons upwards. This problem is usually ascribed to "too much negative air," but it usually means there is a leak in the building envelope. This is common in older buildings with wood floors where the air leaks through from below. One enclosure required over twelve air changes per hour to maintain a 0.02 inches of water pressure differential due to leaks through the wood floor.

It is common to specify and monitor the pressure differential between the enclosure (P_1) and an adjacent space (P_0), but the force that pulls the plastic loose is the pressure differential *across* the plastic, which can differ markedly from that between the enclosure and adjacent spaces. Besides air infiltration from wind, air leaks from elevator shafts and pipe chases, as well as building air currents, can create pressure pulses that will act on the plastic and its adhesive or mechanical fastening system. These conditions should be addressed before the plastic starts going up on the perimeter walls of the removal area. The project monitor should verify that all penetrations to the outside of the building are sealed, and not just to prevent fiber escape. These penetrations, including broken windows, holes for pipes and conduit, leaks around door and window frames, exhaust fans and ventilation grilles, must be sealed against air infiltration *from the outside*.

Fig. 78—Air infiltration through broken window in boiler plant caused plastic sheets to bulge inward.

Fig. 79—Extreme case of air infiltration behind plastic sheets.

The project monitor takes note of equipment and furniture that had to remain inside the enclosure. The specifications should require any visible debris to have been removed, and the project monitor should verify that this was done before the items were covered with plastic. This is sometimes referred to in specifications and training courses as "pre-cleaning," which means cleaning any visible debris from floors and other surfaces before covering them with plastic to protect them during the actual asbestos removal.

Many of the problems discovered at this stage (or later) could have been resolved during project design by specifying the removal from the area of objects that are difficult to protect or clean, or items that are worth less than the cost of doing so. The principles are quite simple:

- If it cannot be removed, it must be protected.
- If it is not protected properly, it must later be cleaned or disposed of.
- It may have to get cleaned anyway.
- If it could have gotten contaminated, it must be inspected.

A case in point is electrical conduit and fixtures that were attached to ceilings or structural members before the plaster or fireproofing was sprayed on. These items are extremely time-consuming to properly clean and inspect. In many cases, the general contractor is going to remove them anyway after the area is cleared. If there is any ACM remaining in the small recesses in and behind these items, there will be a fiber release episode when they are taken down. If the project designer determines that these items are scheduled for removal after clearance, they should be removed as part of the abatement contract.

ASTM E 1368 tells the project monitor some of the places to look for debris that gets past the protective layers of plastic, and the discussion of visual inspection for completeness of cleanup addresses this matter in detail. Better though, that the contractor and project monitor make every effort to prevent the debris from getting through in the first place. A thorough inspection of the preparations at this stage makes subsequent cleanup, and inspection, much easier at the conclusion of the project.

Water is the principal medium that carries asbestos debris into places inside the enclosure where contamination results. All the discussion of the long "settling periods" for microscopic airborne asbestos fibers notwithstanding, the quantity of material thus available to contaminate surfaces by "settling" on them is minuscule compared to the bulk of material mixed with the amended water (see footnote 3, Chapter 2) used for removal and cleaning. Keeping surfaces and items in the enclosure clean means controlling this water.

In determining how to protect surfaces and items inside the enclosure, and how to inspect these preparations, consider the following principles:

- Water runs downhill.
- Surface tension takes water in unexpected directions.
- Water suspends and carries debris.

- Amended water gets in places where ordinary water cannot.
- When the water evaporates, dry debris remains.
- If dry debris is disturbed, fibers become airborne.

The basic responsibility of the project monitor is to examine the plastic covering the floors, walls, and items in the enclosure for folds, creases, and tears that could trap water and debris, which make it difficult to remove the plastic without contaminating the very things it is supposed to protect. "Hospital corners" are the rule in attaching plastic: the smoother and tighter the surface, the easier water and debris can run off it and the easier it is to wipe clean (Fig. 80).

Horizontal strips of duct tape should be backed up with spray adhesive to reduce the tendency of amended water to work its way under the top edge of the tape so that it eventually comes loose. There is a multitude of approaches to keeping plastic on the walls, such as by nailing the plastic to the wall with furring strips, and large, heavy hangings of plastic may need such reinforcement. Remember: 6-mil (0.15 mm) plastic is heavier than 4-mil; two layers weigh more than one; and the higher the wall, the heavier the plastic. Figure 81 shows a wall being covered with a long piece of plastic, and if part of the plastic starts to pull loose, the remaining duct tape or adhesive may not be strong enough to prevent progressive failure of the bond to the wall. Another approach, besides mechanical fastening, is to attach the wall plastic in 10-ft (3 m) wide sections, which minimizes the amount of plastic that can fall due to a single case of adhesion failure, and also limits the resulting contamination of the wall.

Figure 82 shows an 18-ft (6 m) high wall being covered with a sheet of plastic, held in place by a considerable amount of duct tape and spray adhesive. Figure 83 shows a well-prepared interior wall where the contractor has foamed the top of the plastic to keep water from getting behind it.

Furniture, fixtures, and equipment that remain inside the enclosure need to be protected and inspected. Some specific examples:

- Items along the wall, such as radiators, fan-coil units (Fig. 84), and baseboard heaters, will be covered by the wall plastic, but should have their own layer of protection before the wall plastic goes up over them (Fig. 85). If the wall plastic comes down and debris gets into these fixtures, they will be extremely difficult to clean and inspect, and very expensive to replace if they cannot be cleaned.
- Electrical panels and controls, telephone equipment and junction boxes in conduit runs should be de-energized,

Fig. 80—Plastic for enclosure securely taped flat against walls and floor.

Fig. 81—Long expanses of plastic are difficult to keep attached to the wall.

Fig. 82—Plastic being installed on wall in warehouse.

Fig. 83—Plastic on wall foamed in place at top.

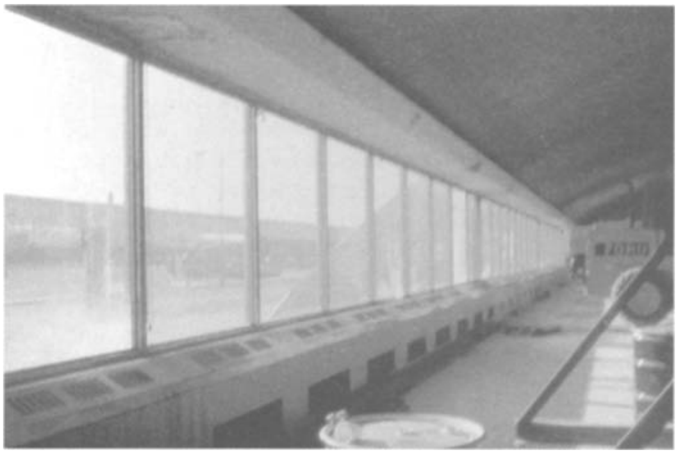

Fig. 84—Openings on top of fan coil units will catch water if wall plastic falls down.

Fig. 85—Covering fan coil units with plastic to keep water and debris out.

then protected by plastic sheets or rigid barriers. Power should be cut off from outside the removal area, lest someone inside the enclosure decides to turn the lights back on (switches can be operated through plastic sheets). Sometimes it is not possible to de-energize these items, and it may also be necessary to provide cooling air to them. Whether this requires forced air from a fan or just a flap over an opening depends on the equipment and the configuration of the enclosure. If the opening is within "splash distance"—the distance that water sprayed for removal or cleaning can travel—the opening to the equipment must be protected from water that could damage and contaminate the equipment.

- Figure 86 shows the installation of a layer of plastic sheeting over battery-charging stations in a warehouse. This equipment could not be moved and was, of course, de-energized, but it was imperative to keep water and debris out of it. After this layer of 6-mil (0.15 mm) plastic was in place, an additional layer of 6-mil (0.15 mm) plastic was attached to cover it and the rest of the wall (Fig. 87).
- Light fixtures are often wrapped to keep them clean (Fig. 88), but this is usually ineffective in keeping amended water and debris out. The fixture is usually left dangling by its wires, with penetrations in the plastic around the wires or whatever else is holding it up. Water leaks into these penetrations and the result is a plastic bag containing a contaminated light fixture and some amended water. The fixtures should be removed during area preparation, and then reinstalled by a licensed electrician after the area is cleared.

Fig. 86—Installing plastic sheeting over battery charging equipment.

Fig. 87—Covering rest of wall above battery charging equipment.

Fig. 88—Light fixture suspended from ceiling and wrapped in plastic.

- Sinks and toilets should be covered to remove the temptation to use them for disposal of contaminated water. Sanitation facilities outside the enclosure should be used for personal relief.

The *minimum* protection for floors is two layers of 6-mil (0.15 mm) plastic, and this applies only to floors that will not be damaged if the plastic leaks such as the concrete floor in Fig. 89. Perhaps one should say "when" the plastic leaks: projects where it does not are more the exception than the rule. This may be the leading cause of problems on abatement projects, considering the potential for tearing floor plastic and the consequences. Large and small items of equipment from shovels to scaffolds are dragged, scraped, and rolled across the plastic and the taped seams. If the floor is linoleum, terrazzo, concrete, or a similar *continuous* surface, debris is relatively easy to remove if the plastic gets torn. Floor *tile* presents a more complex situation, because water can get between and under the tiles. If the tile or mastic contains asbestos and their removal is part of the project, do that first (see Chapter 5) and then put the plastic down on the clean slab before removing the friable ACM. However, an owner who does not want to have the tile removed will not be amused to find out that some of it has come loose once the plastic is pulled up.

Hardwood floors, such as those found in gymnasiums, require special precautions, as the issue is not just cleaning, but physical damage to expensive materials. The preferred approach is to put down a layer of 6-mil (0.15 mm) plastic, then a layer of plywood, chipboard, or other material strong enough to take the loads imposed by the equipment, then two more layers of 6-mil (0.15 mm) plastic. Plan on throwing the plywood or chipboard away as contaminated waste; it will get wet when the plastic rips, but the floor will survive. Cardboard is inadequate: it gets ripped and soaked. Carpeting should be removed before the plastic goes down. It can be re-installed or replaced after the project is over, or protected with the measures described for hardwood floors. The implications of contaminated carpet are discussed later in this chapter.

The obvious consequences of the floor plastic getting ripped are contamination of the underlying floor, additional cleaning and inspection, and possible damage that must be repaired. It gets worse when you realize where the water can go. There are holes in floors that pipes, electrical conduit and other services go through (Fig. 90). Although they are supposed to be sealed with fire-stop, they cannot be relied on to be watertight. If they are not, water and debris will be carried through them to contaminate the space below, or cause ceilings to collapse and other damage. Furthermore, there may be ACM in the form of fireproofing or plaster in the plenum into which the water runs. Surface tension will cause the water to follow horizontal pipes and run off at some distance from the penetration. Extensive contamination, damage, and cleanup efforts have, in fact, occurred from this problem, resulting in some very anxious and upset occupants of the affected spaces. This is one reason that some go as far as to vacate the floor below where asbestos is being removed. All accessible floor penetrations, as well as the base of the walls and bottoms of doors, should be caulked watertight before the plastic goes down. Many buildings have ducts built into the slab for electrical, communications and other services (Fig. 91) and these openings need to be sealed against water penetration.

The project monitor should pay particular attention to the location and construction of the decontamination facilities, commonly called the "decons." Some project designers leave the layout of the decons to the contractor, many of whom construct perfectly acceptable—sometimes, in fact, quite impressive—facilities. Figure 92 shows the decons for a large enclosure where the ACM was 35 ft (12 m) above the floor in places. The chamber on the left is the personnel decon used by workers and others entering and exiting the enclosure. The chamber on the right is the "load-out" for taking equipment in and out, and for removing waste material. The reason this load-out was so large is that it was used to take the electric man-lifts into and out of the enclosure.

The personnel decon in Fig. 92 provided generous space for removing one's contaminated clothing, showering and toweling off. However, I have seen clean rooms the size of a telephone booth set up for a crew of twenty, with equipment rooms and showers that were simply too small for the number of people they would have to handle. Prefabricated, collapsible decons are quite often deficient in the amount of space they provide. If the decon has a solid unvented door, as with trailer-mounted units, the main source of make-up air for the negative air machines will be cut off as soon as the

Fig. 89—Covering concrete floor with sheets of 6-mil plastic.

Fig. 90—Floor penetrations for pipes and conduit.

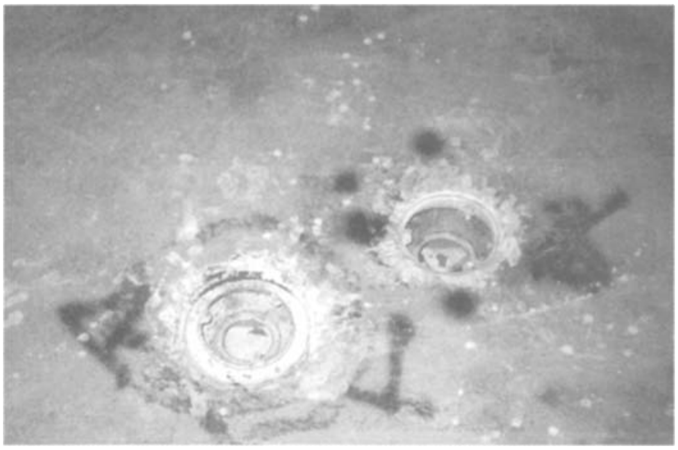

Fig. 91—Holes for access to wiring duct in slab.

Fig. 92—Decontamination facilities for large enclosure.

door is closed. This could exacerbate the problem discussed earlier of keeping the wall plastic attached, unless an alternate source of make-up air is provided.

In one sense, the decons are the last line of defense against contaminating the building and they handle a lot of traffic and abuse, so they must be easy to clean and ruggedly constructed. Decons have been located *inside* the enclosure directly under a ceiling to be scraped, guaranteeing that they will become contaminated unless covered by a rigid, sloping roof for water to run off. The project monitor might also want to keep in mind that he will be using these facilities himself regularly throughout the project. To repeat a note of reality from Chapter 2, workers seldom suit up in the clean room, but do so in the area immediately outside the decon, simply because there is more room. On the way out, they vacate the clean room quickly to get out of the way of the guys behind them. As long as privacy and security of personal items are provided for, there is nothing wrong with this arrangement.

One of the easiest ways to contaminate the shower and clean room is to bring bags of removed ACM, other waste, and equipment out through them. These areas should be used only by people going into and out of the enclosure. The shower is not to be used to wash debris off bags, tools, ladders, etc. Every enclosure should have a load-out area for this purpose, as defined in ASTM E 1368:

> "A structure attached to, but not within, the abatement area into which containers of removed material are passed and stored for subsequent transfer to a truck for disposal."

A load-out is highly recommended even if all of the contractor's and project monitor's equipment would fit through the shower. The load-out area is preferably located at a different exit from the enclosure than the decon used by personnel. If only one exit is available, the load-out area and personnel shower can both be attached to the equipment room.

Another way to contaminate the clean room is to arrange the shower so that the user steps back out onto the same floor that he stepped in from. This will ensure that asbestos debris is tracked into the clean room. Prefabricated stall showers that open only on one side are the usual culprits in this problem. To avoid this, the shower should be installed so that the user passes through the shower by stepping in on one side and out on the other. Make sure the water can be turned on and off from outside the enclosure—hoses have a tendency to spring a leak after the last person has left the enclosure and showered out.

Regulations and training manuals state that the chambers of a personnel decon facility should be separated from each other and from the enclosure itself by "airlocks." Opinions differ as to what constitutes an airlock. To some, it is a set of three over-lapping 6-mil (0.15 mm) plastic sheets, secured at the top and along alternating sides of a doorway or frame. The concept is that as a person weaves through this maze the flaps close around him and prevent contaminated air from escaping. A single sheet of plastic hanging over a vertical slit in another sheet taped across a doorway stretches the definition of an airlock.

Others maintain that an airlock is a separate chamber between two parts of the decon. Putting one such airlock between the equipment room and shower and another between the shower and clean room turns a three-chamber decon into a five-chamber one. Figure 93 shows three of the five chambers of such a decon. The clean room and shower (dark plastic) are shown with an airlock (light plastic) separating them. The other airlock and the equipment room are behind the wall to the right.

The specifications should dictate when to commence using the decontamination facilities, as well as respirators and protective clothing. This should happen as soon as there is a possibility of disturbing the ACM, which can occur during preparation. Workers find it difficult to attach the plastic to the top of the wall without bumping their heads on the fireproofing (Fig. 94) or acoustical plaster, necessitating not only hoods, but full protective clothing and respirators. Sometimes, "spot removal" of small amounts of ACM is necessary even to construct the enclosure, calling for special precautions that are discussed in Chapter 5. Thus, the workers and the project monitor may be required to don respirators and protective clothing, and to begin decontamination procedures, well

Fig. 93—Portion of five-chamber decontamination unit.

Fig. 94—Work this close to ACM requires personal protection.

before any scraping or other removal of ACM actually starts. The project designer should indicate in the specification the point at which this occurs, and discussions between the contractor and project monitor are advised during preparation.

The specification should require inspection and approval of preparations by the project monitor before removal of asbestos actually starts, and some jurisdictions require such an inspection by an enforcement agency at this time. As the foregoing makes clear, however, the process of visual inspection at this stage of the project must start early, be thorough, and continue through the preparation activities.

Inspection During Asbestos Removal

To recapitulate, begin surveillance during preparation of the work areas, including construction of barriers and protection of surfaces inside the enclosure. Maintain this surveillance throughout the removal phase to detect conditions which, if not corrected, may affect the integrity of the critical barriers and their ability to prevent contamination of occupied areas of the building. Such conditions also reduce the likelihood of passing the visual inspections at the conclusion of the project. ASTM E 1368 recognizes that conditions of cleanliness, work practices and barrier integrity, affect airborne fiber levels inside and outside the enclosure. These conditions are monitored by taking air samples.

There is a tendency to find false comfort in low fiber counts, even when visible debris is present in areas that are supposed to be clean or when obvious breaches of critical barriers exist. Such situations do not obviate the need for visual inspection and cleanliness, nor for barrier integrity and air sampling. The occasional congruence of visible debris, barrier failures and high fiber counts (meaning there was a sampling pump in the right place at the right time) drives home the need for enforcing the visual cleanliness and barrier integrity provisions of the specifications. On one project, workers were tracking debris past the shower into the clean room, and airborne fiber counts in the clean room rose and fell as the decontamination facility got dirty and was cleaned. This situation illustrates the use of air monitoring as a project management tool for the owner's representative, not just for OSHA compliance and clearance sampling. If the specifications establish airborne fiber limits during removal, above which corrective measures must be taken, the project monitor's authority to enforce this provision must be delineated.

A project monitor's time at the site is finite and the more time spent outside the enclosure setting up air pumps the less time is available to be inside the enclosure observing the removal and clean-up. A trade-off must be made as to where this time is most effectively spent. Sometimes "ambient" air samples are required to be taken outside the perimeter of the enclosure (Fig. 95), including in occupied areas of the building, with high-volume air sampling pumps. Is it more important to collect these samples, perhaps continuously, to detect a breach in a critical barrier, or is the time better spent inside the enclosure helping to ensure that a breach doesn't occur or is promptly detected and repaired? Shouldn't low fiber levels be enforced inside the enclosure so that a breach, if it occurs, won't have serious consequences? Probably the least productive use of the project monitor's time is taking air samples at the exhaust of the negative air machines, for reasons explained in ***Monitoring Negative Pressure Exhaust***. Sidebar 4.

The contractor's responsibility during this phase is to remove the ACM according to the contract documents, to maintain an appropriate degree of cleanliness and to maintain the integrity of the critical barriers. The project monitor's job is to verify that these things are done. It is important to establish contractually the amount of time that the project monitor will spend at the site, and what happens if site

Fig. 95—Ambient air sampling pump outside critical barrier.

Sidebar 4—Monitoring Negative Pressure Exhaust

Taking samples of the negative air exhaust at abatement sites is usually a waste of the project monitor's time. Figure 96 shows a typical placement of a filter cassette for such a sample, for which the results are totally meaningless.

Ask someone the reason for taking these samples and you will be told: "To make sure the negative air machines are working." That can be determined by reading the pressure differential monitor or by looking at the plastic flaps on the airlocks to see which way they are deflected—inward if the enclosure is under negative pressure relative to the outside.

What do the fiber counts from the negative air exhaust tell about the performance of the negative air machine? High fiber counts might reveal a leaking seal or a hole in the HEPA filter if similar samples were available with the system intact. But these system failures can be detected by looking at the pressure gauge on the machine. Do low fiber counts in the exhaust indicate low fiber levels inside the enclosure? Personal and area samples taken inside the enclosure are a direct way to measure this. To my knowledge, no one has ever published a correlation between air samples taken in the duct or at the exhaust of a negative air machine and fiber levels inside the enclosure, or quantitatively related these samples to the performance of a negative pressure enclosure.

One reason may be the difficulty of measuring fiber concentrations inside the duct or close to the end, which is where most samples are taken. Sampling particulates in a moving airstream is far different from doing so in still air. The samples must be taken *isokinetically*, meaning that the velocity of air drawn into the sampling device is the same as in the duct itself, if the "freestream velocity" in the duct exceeds 1000 ft/min (305 m/min) [1]. In a 12 in. (0.3048 m) diameter exhaust duct from a negative air machine operating at a flow rate of 1500 ft^3/min (42.47 m3/min), the freestream velocity is 1900 ft/min (582 m/min). The velocity of air being drawn into a 25mm (one inch) cassette with a pump set at 2 liters/minute (0.07 ft^3/min) is 17 ft/min (5.2 m/min); with a 10 L/min pump (0.35 ft^3/min) it is 85 ft/min (26 cm/min). These are nowhere near isokinetic conditions, and the cassette will grossly over-sample the larger particles in the duct. The airflow in the duct will see the cassette as a plug and go around it, while the inertia of the particles will cause them to leave the airstream and enter the cassette. Fibers large enough to be counted by Phase Contrast Microscopy—over 5 μm long—will be over-sampled. Taking isokinetic samples is an art, as anyone who has done stack sampling for air pollutants can attest. It is far too complicated for an abatement site, even if a much larger cassette and pump were used. Samples taken non-isokinetically in the exhaust ducts of negative air machines, which includes just about all of those taken at abatement sites, are meaningless.

It does make sense to sample the exhaust from a negative air machine if it is being discharged into an unoccupied space inside the building. To get a valid sample, place the cassette at least eight duct diameters downstream of the end of the duct to eliminate the effects of turbulence in the airstream. It makes less sense to take samples outside the building, especially on upper floors. Even at ground level, trying to sample eight feet (2.44 m) downstream of the end of a duct discharging out a door or window might require placing the pump on or across a sidewalk or curb. Unless the samples are analyzed by TEM and other sources such as vehicle brakes are accounted for, outside samples tell you nothing about the operation of the negative air machines. ◆

Reference

[1] Air Sampling Instruments for Evaluation of Atmospheric Contaminants, Fourth Edition. American Conference of Governmental Industrial Hygienists, Cincinnati, OH. 1972.

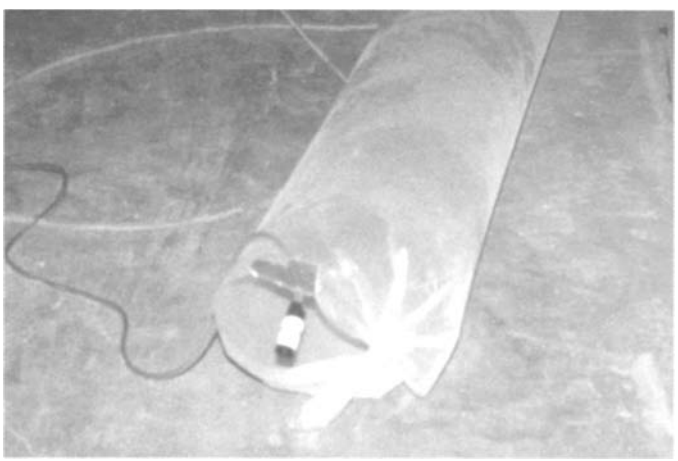

Fig. 96—Filter cassette in negative air exhaust.

conditions indicate that this amount is insufficient. The owner may require full-time surveillance or state regulations may insist that someone be there whenever the contractor is on site. As a project monitor, your day at the job site generally goes as follows.

Upon arriving at the site, confer with the contractor's supervisor regarding status and problems, put filter cassettes on the air pumps outside the enclosure, and start the pumps. You cannot monitor the progress of an abatement project from outside the enclosure, so suit up and go inside. On the way in, take note of the cleanliness of the decontamination facility, or lack thereof.

Some specifications and regulations require that "viewing ports" of clear plastic be installed to permit observation of activity inside the enclosure by unprotected persons. These viewing ports may be convenient for casual visitors to observe progress, but in no way do they substitute for actually going inside the enclosure to monitor the work. The workers inside and outside the enclosure frequently communicate with one another by shouting across the viewing port (Fig. 97). However, it is not possible to determine if the material has been properly wetted by looking through a viewing port, nor can you see what is happening around the corner and out of sight.

Once inside, look around briefly to see who is doing what, talk to the supervisor if he is in there, and select a couple of workers for personal sampling. These samples are not for the contractor's OSHA compliance monitoring, which should *never* be done by the project monitor. Their purpose is to provide an independent evaluation by the project monitor of the effectiveness of the contractor's fiber control measures. Some specifications require area samples inside the enclosure but a stationary pump located far enough from where the asbestos is being removed to be out of the worker's way will yield fiber counts up to an order of magnitude lower than personal samples taken on that worker.

After the pumps are running, walk around and inspect the condition of the plastic on the walls and floors—if it is torn or falling down, call it to the supervisor's attention. (Never communicate directly with a worker unless asked a question, or in case of an egregious breach of regulations or

Fig. 97—Viewing port seen from inside enclosure.

a serious safety hazard.) Check the condition of the HEPA-filtered exhaust units, as ducts come loose, doors come unlatched, cords get unplugged, and power failures occur. Check for safety hazards from electrical circuits, ladders, and scaffolds, and observe the workers' use of respirators and the condition of their protective clothing.

Monitor the progress of the removal and the cleanup of the removed material—large quantities of gross debris and water should not be accumulating on the floor or other surfaces. Bags of water and debris left standing around will leak as soon as the enclosure is unoccupied. In short, the integrity of the enclosure and critical barriers against leakage of airborne fibers and waterborne debris is the first priority during these inspections. Encouraging the supervisor to keep the work area clean on a daily basis will lessen the chance for a frantic cleanup effort later to get ready for the inspections.

It takes about an hour or two to do all of these things inside the enclosure. By that time enough air volume has been collected on the personal samples, so gather them up and leave the enclosure. After showering out, collect the filters from the area pumps, debrief the supervisor on what you observed, and record your findings in the Daily Project Log.

The work that is going on during this phase is illustrated by the following pictures. In Fig. 98, workers are scraping off acoustical plaster, while others are promptly putting it in bags (Fig. 99). The workers in Fig. 100 are removing fireproofing, while the one in Fig. 101 is cleaning overspray from the deck.

> "In order for something to become clean, something else must become dirty . . . but you can get everything dirty without getting anything clean" [4].

The removal area is going to get dirty—sometimes, very dirty—during this phase of the work. The project monitor has to decide how dirty is *too* dirty, and let the supervisor know when things are getting out of control. This practice will also facilitate adherence to one of the three basic methods of compliance in the OSHA regulations: "Prompt clean-up and disposal of wastes and debris contaminated with asbestos in leaktight containers." Piles of removed material and debris should never be allowed to remain in the enclosure to the extent that they hinder the movement of workers and equipment.

Fig. 98—Abatement workers scraping acoustical plaster from ceiling.

ASTM E 1368 states

> ". . . The removed material and contaminated water must not be allowed to accumulate inside the regulated area, but must be bagged or otherwise collected in water-tight containers as soon as practicable."

Fig. 99—Abatement workers putting removed plaster in bag for disposal.

Fig. 100—Abatement workers scraping fireproofing from beam.

Fig. 101—Abatement worker cleaning overspray from deck.

The standard "water-tight container" is the familiar 6-mil (0.15 mm) plastic labeled disposal bag. Is it up to the task?

For "adequately wet" (the quotation marks indicate that the term is open to interpretation) removed ACM, these bags *by themselves* are acceptable as the first repository while inside the negative pressure enclosure. They are not acceptable for containing wet ACM for any length of time in an unattended enclosure, as experience has shown that they will leak. They are not acceptable for containing wet ACM mixed with any items having sharp edges, such as ceiling grids, pipe hangers or metal lath, as experience has shown that they will tear. Bags of removed ACM, with or without sharp objects, must be placed in two 6-mil (0.15 mm) plastic bags (referred to as "double-bagging") and then put into rigid or tear-proof containers. This is normally done in the load-out after the bags are evacuated and the outsides have been washed.

A cardboard box is not a rigid container—it will fail if a bag leaks. Fiber (Fig. 102) and metal drums are preferred and can be re-cycled from the landfill if the bags don't leak. Some contractors use one-cubic-yard (0.76 m^3) "bulk bags" of reinforced plastic and heavy fabric, each of which holds a large number of 6-mil (0.15 mm) disposal bags (Fig. 103). Providing that equipment is available to move the heavy bulk bags when full, they are an efficient means of storing and transporting asbestos waste.

Fig. 102—Six-mil disposal bags go into fiber drums for disposal.

Fig. 103—One-cubic-yard bulk bags used for transport and disposal.

If permitted by regulations, contaminated waste such as plastic sheets, disposable clothing, towels, etc. can be placed in single 6-mil (0.15 mm) labeled plastic bags, providing the waste is dry or does not contain enough water to leak out of the bag if it gets torn. These bags do not have to go into rigid containers for transport and disposal, but if a bag is torn it should immediately be put into a second bag.

Removed ACM and contaminated waste should be taken promptly to the landfill and not allowed to accumulate at the site. The project monitor should keep track of the number of containers picked up by the waste transporter for comparison to the manifest when it comes back from the landfill. The building owner, whose name is on each container's label, is responsible for the waste. Another advantage of the bulk bags is that they can be off-loaded at the landfill using the truck's tilt mechanism without rupturing (Fig. 104). Drums and loose bags should be unloaded by hand, but never thrown into the landfill.

Items that were supposed to be kept clean, but were not, should be cleaned and properly re-wrapped (or removed) as soon as they are found to be contaminated. This happened to the light fixture in Fig. 88 when fireproofing was scraped from the deck above it. Continued exposure to water and debris may result in having to discard these items before the final cleaning and inspection. If they are attached to a ceiling that has asbestos-containing plaster or fireproofing, they

Fig. 104—Bulk bags being unloaded at landfill.

must be removed as part of the abatement procedures under protective conditions, as in Fig. 105.

Figure 106 illustrates what happens to plastic after a few days of physical abuse and moisture unless it is firmly secured. The plastic is starting to come down in a corner and debris is contaminating the wall and floor. An alert project monitor will notice such a problem before it gets out of hand, as in Fig. 107, and a responsive supervisor will tell his crew to "stop scraping and start taping!"

The supervisor will want to know if the removal is progressing according to the expectations of the project monitor

Fig. 105—Abatement workers removing light fixture from ceiling.

Fig. 106—Plastic hanging loose from wall during asbestos removal.

Fig. 107—Wall plastic has fallen completely away and carpet is contaminated.

and he deserves an honest and timely reply. Look closely at the abated surfaces (substrates and components from which asbestos has been removed) and decide if they would pass a visual inspection for completeness of removal (which will be discussed in the next section). Making it clear that this is not the "official" inspection, show the supervisor areas such as Fig. 108 that represent acceptable completion of removal and other areas such as Fig. 109 that do not. At this stage, it is very important to communicate carefully with the supervisor, lest he read too much into your comments about the progress of the work. Emphasize that you are not passing all or part of the removal as complete at this time and that you will be making a more thorough inspection later that "counts." Most importantly, let the supervisor know that it is not time yet to apply the sealer, or to "encapsulate" as they are prone to call it.

Gross removal and cleaning of the abated surfaces in a single enclosure will take a couple of days to four weeks at the most. Taking longer than four weeks from completion of preparation to the first inspection pushes the limits of a reasonable size for a single enclosure. Of course, more than one area may be under containment at a time on large projects, and inspection can begin in one part of the enclosure while removal and cleanup continue in other parts. Because the condition of an enclosure tends to deteriorate with time, the amount of plastic that must stay up, the floor space to be

Fig. 108—Grooved ceiling cleaned of excessive residue.

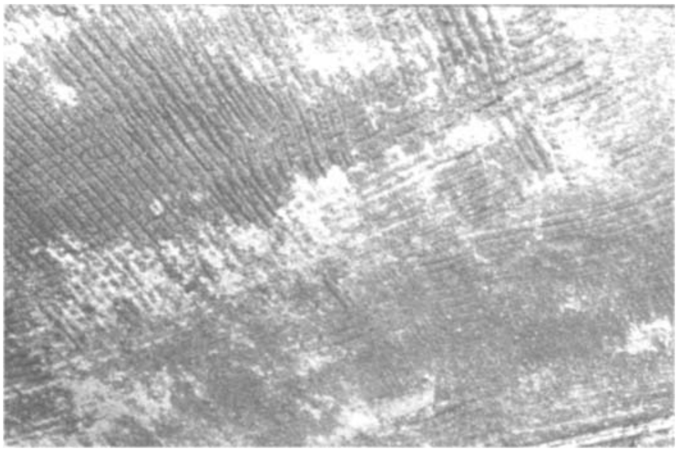

Fig. 109—Grooved ceiling with excessive plaster remaining.

kept clean, and the volume of air to be exhausted should not exceed the contractor's resources of manpower, equipment, and time. These factors will affect the workload of the project monitor proportionately.

By this time the project monitor has a pretty good idea if the work has been going according to plan, if the contractor has been competent and cooperative, and if the work promises to get done on schedule. If there have been delays and disputes, it will also have become apparent that the building owner is not pleased with the situation. See ***Unexpected Situations.*** Sidebar 5 for a discussion of things that can go wrong and what to do about them.

Inspections at the Conclusion of the Project

The part of ASTM E1368 titled "Completeness of Abatement" requires two visual inspections: the first for completeness of

Sidebar 5—Unexpected Situations

Construction projects have led to disputes since time immemorial and asbestos abatement continues the tradition. There will be times when the contractor did things the way he thought the contract documents required and found out after the fact that the consultant and owner had other ideas. Not surprisingly, these situations often result in claims and litigation when the contractor attempts to recover the cost of complying with the owner's demands. Some examples follow.

Conditions not anticipated during project design—Discovery of ACM not covered in the scope of work may result from an oversight during the building survey or project design, from instructions by the owner not to destructively inspect concealed spaces, or because such spaces were only rendered accessible after abatement started (Fig. 110). One project eventually involved more demolition than asbestos abatement as the contractor kept finding walls behind walls in a hundred-year-old building (Fig. 111), requiring a check of every newly-discovered wall for asbestos in the plaster as soon as it was accessible. One wall was so thin it crumbled when they scraped the paint off and the whole wall had to come out inside a negative pressure enclosure. Such conditions are impossible to anticipate without an extensive amount of destructive testing during the Project Design Survey.

As the owner's representative, the consultant will be expected to recommend change orders for the additional work. Careful documentation of the location and amounts of the newly-discovered ACM by the project monitor is very important, as the building owners may be reluctant to absorb all or part of the additional costs in these situations. Whether the material should have been found during the building survey and included in the original scope of work is a common complaint of owners against consultants in litigation. Also, OSHA regulations detail the responsibilities of the abatement contractor and building owner to notify workers and occupants of such newly discovered ACM. As the owner's representative, the consultant may inherit the details of the notification process, and familiarity with the OSHA requirements in 29CFR1926.1101(k) is advised.

Excessive deterioration of site conditions—King Hammurabi of Babylonia (1955–1915 B.C.) wrote what has been called the first building code: the Code of Hammurabi. Article 229 states:

> "The builder has built a house for a man and his work is not strong and if the house he has built falls in and kills a householder, that builder shall be slain [1]".

Putting such a clause in the abatement contract would vividly focus the contractor's mind on his responsibility to comply with the specification and regulations, not that I advocate such harsh penalties. Sometimes conditions inside the enclosure deteriorate to the extent that continuation of removal is simply unacceptable. This is the infamous "STOP WORK" situation, and boilerplate terminology in some specifications and contracts gives the owner's representative the authority to "shut the job down." It may be that simple in the world of conventional construction for a contractor to walk away from the job site, but it does not work in asbestos abatement. If the workers are pulled off the site, the conditions in the enclosure will rapidly deteriorate and the chances of contaminating the building could very well increase. To maintain the integrity of the enclosure, the negative air machines have to be kept in operation, plastic has to be put back up on the walls, and water and debris have to be collected for disposal. It takes manpower and access to the site to do this.

ASTM E 1368 has the following to say on this topic:

> "If anyone other than the building owner has the authority to stop the contractor from removing asbestos-containing material and require the contractor to correct violations of the specification or regulations, this must be clearly stated in the contract documents."

and

> "The project monitor must report work practices not in accordance with the contract documents, citing the applicable page and paragraph number of the document, and also any potential violations of federal and state regulations."

This is a topic on which the project monitor's responsibility and authority must be extremely clear in the contract documents, and the situation calls for a calm, professional demeanor, above all. If the project monitor determines that the work is being performed in egregious violation of the specification and regulations, and is unable to resolve the matter with the supervisor, the project monitor should then convey the *owner's* instructions to the contractor to *stop removing asbestos* and restore the integrity of the containment and conditions of cleanliness to conform to the contract documents. Because of the actual or perceived delay this will cause, the contractor may claim additional compensation or time, or liquidated damages may be imposed by the owner. This makes the project monitor's documentation of conditions extremely important.

Sidebar 5—Unexpected Situations—*continued*

Figure 112, taken from an old training program, has been widely reproduced as an example of a "typical" abatement project. If these conditions are typical, no wonder people have developed an abiding fear of asbestos removal. This photograph shows unacceptable conditions that should cause the owner to immediately order the contractor to stop removing asbestos, clean the place up, and correct some blatant work practice and safety violations, namely:

- The lights are on. The ones on the left are not covered, and wet plaster scraped off the ceiling has fallen into them.
- There are no guardrails on the scaffolds. To reach the ceiling over the lights, one of the workers on the left scaffold had to stand on the top plank.
- The planks on the right scaffold extend past the rails a good 3 ft (1 m) on the left side. Imagine both workers taking a couple of steps in that direction at the same time.

These conditions would have to be corrected before asbestos removal resumed. Such a situation should be amenable to resolution between the contractor's supervisor and project monitor without the owner's intervention. More serious or extensive violations, or failure of the contractor to correct them, would warrant the owner's attention. ♦

Reference

[1] James G. Gross, Developments in the Application of the Performance Concept in Building, Proceedings of the 3rd International Symposium-Application of the Performance Concept in Building, Tel Aviv, Israel. December 1996.

Fig. 110—Pipes in wall discovered during abatement.

Fig. 111—Demolition of walls in old building revealed more walls.

removal and the second for completeness of cleanup. A flow chart earlier in this chapter (Fig. 68) shows how these inspections fit into the sequence of abatement activities. The remainder of this chapter will focus on the time from final removal of ACM and residue from abated surfaces and components through final air sampling and dismantling of critical barriers and decontamination facilities. For a large project involving multiple areas, these activities would be performed as work in each area was completed.

The cleanup and inspection sequence may vary from the flow chart if the specification or regulations dictate, as they

Fig. 112—Unacceptable conditions in removal area—work practices and safety hazards.

take precedence over ASTM E 1368. If the specification or applicable regulations require additional steps in the sequence, they should be shown on a modified version of this flow chart. Many state regulations and "master specifications" require *a* visual inspection, but none of them forbid you from conducting *two* visual inspections as ASTM E 1368 requires. There will be differences, however, as to when other activities are performed relative to visual inspection. For example, Vermont regulations [5] state in ¶2.4.2(H) that

> "The process of applying lock-down encapsulant materials may follow only after the work area has been visually cleared and has met an acceptable clearance level as detailed in 2.4.2(s)."

ASTM E 1368 requires that clearance air samples be taken after all plastic has been removed from walls, floors, furnishings and equipment, which is not the time to be spraying "lock-down encapsulant."

Before commencing the visual inspections, it is a good idea to lead the supervisor through the sequence in the flow chart, and be prepared to reinforce the message through repetition. Look at the situation through his eyes: he and his crew have worked long and hard, they think they are almost done, and they want to get out and go home. With all due respect to their impatience, however, the project monitor,

not the contractor, should set the tone and pace of the inspections. To repeat Yogi Berra's oft-quoted maxim: "The game ain't over until it's over." An abatement project is not over until after the visual inspections and final air sampling are complete.

ASTM E 1368 requires the project monitor to be available and prepared on *reasonable* notice to conduct the visual inspections and the project monitor should be given adequate notice for an inspection. Project monitors are often called late in the afternoon to be told, "We're ready for your inspection and air samples" and expected to work late into the night and clear the area by morning so the contractor could tear down and leave. ASTM E 1368 requires the competent person and a worker to assist the project monitor, so everyone will work into the night to get the job done under such conditions. While some flexibility on schedule is required, no compromise on the thoroughness of the visual inspections should be tolerated.

There are items of equipment, such as ladders, scaffolds, man-lifts, etc., that are not practical for the project monitor to furnish and that would duplicate equipment that the contractor already has on-site. These should be identified in the specification and made available for the visual inspections.

Complete Removal of ACM and Surface Residue

The workers will have completed this step before the supervisor requests the first inspection. Depending on the type of ACM involved, they will have done work such as the following:

- Scraped fireproofing off beams, columns, decks, and walls;
- Scraped acoustical plaster from ceilings and brushed it out of the grooves in the scratchcoat;
- Removed pipe insulation, including straight runs and molded fittings (mudded joints, to some) on elbows, tees, valves, hangers, etc.;
- Removed blocks of duct, fan, breeching and boiler insulation, or asbestos skim coats with the underlying fiberglass;
- Removed any other type of ACM as called for in the contract documents.

The workers will have removed the bulk of these materials in gross form and cleaned the abated surfaces and components by washing, wiping, and HEPA-vacuuming. They will also have removed residue from crevices, cracks, corners, holes, seams, joints, recesses, connections, gaps—any nooks and crannies where asbestos may have gotten lodged during installation or use, or been carried as debris by amended water during removal. This "detailing" can be the most labor-intensive and time-consuming part of the abatement project (Fig. 113). Nor is just detailing involved: the workers need to get this material out of the places the project monitor will look, and where the leaf blower will blast during aggressive air sampling. The best way to do this is for the contractor to use a leaf blower during the final cleanup. Obviously, this is not the same leaf blower that the project monitor will use for aggressive air sampling for final clearance.

All surfaces inside the enclosure remain protected by plastic sheets, the critical barriers and decontamination facilities are in place and in use and the enclosure is still under negative pressure. Everyone inside the enclosure, including the project monitor, wears respiratory protection

Fig. 113—Final cleaning of fireproofing residue.

and protective clothing. Some specifications and regulations require one layer of plastic to be taken down at the completion of "gross removal," and this is acceptable as long as at least one more layer remains in place. Remember that the sealer has not been applied yet, and a layer of plastic has to be in place when that is done.

Let us now proceed to the first of the visual inspections.

Inspect for Completeness of Removal

The competent person (the supervisor) and at least one worker with cleaning materials are required to accompany the project monitor and also to provide certain equipment for the project monitor's use. To prepare for the inspection, the supervisor should make sure that ladders and scaffolds, if needed, are in the area to be inspected, that temporary lighting is in place and working, and that workers are present with cleaning materials, including a HEPA-filtered vacuum. It is important to have enough manpower and materials for the inspection to proceed at the pace established by the project monitor (or project monitors if the area is sufficiently large).

In addition to the equipment that the *contractor* should supply for the inspection, what should the *project monitor* provide for his own use? ASTM E 1368 suggests the use of a "small screwdriver or other sharp, pointed tool" for poking into various places to dislodge residue and debris (Figs. 114 and 115). Conduct an "aggressive" inspection by physically disturbing the abated surfaces and components in the same way as during aggressive air sampling. Where pipe insulation has been removed, the pipes will be loose: shake them to dislodge debris from the hangers and other places. Visible debris revealed during the inspection is cause for requiring the contractor to re-clean the surface or component.

The tools and techniques used for inspection are limited only by the situation and the project monitor's judgment, within reason: do not be so aggressive during the inspection that you damage or alter the substrate or component. The project designer is cautioned to allow the project monitor some flexibility by not limiting the tools and techniques to a specific list of items. If the specification says that the project monitor will wipe the surface with a cloth and he starts using a brush, the contractor may claim that the inspection is excessively strict and, therefore, in violation of the contract.

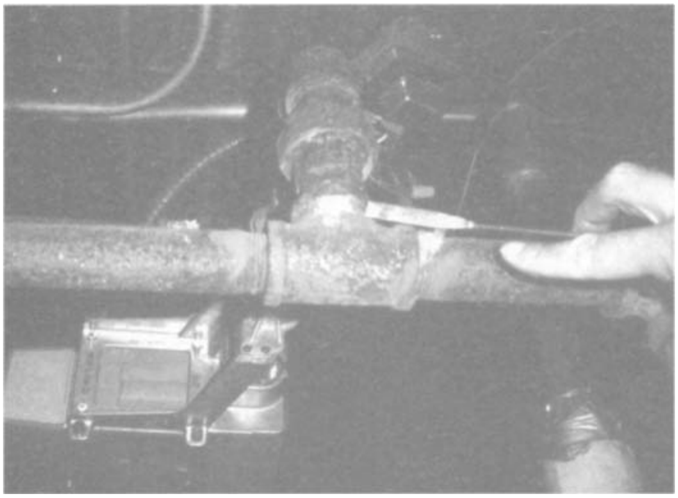

Fig. 114—Laboratory spatula used for dislodging residue from surfaces and components.

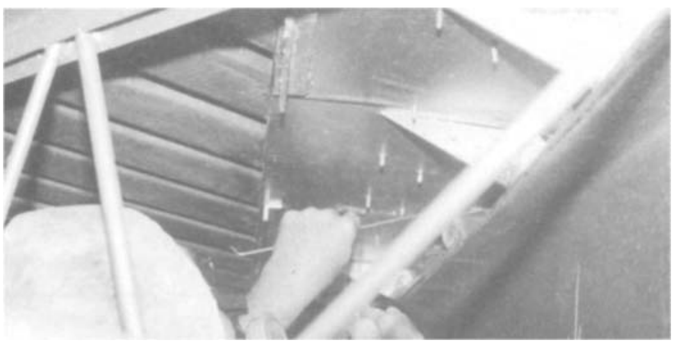

Fig. 115—A thin rod used to dislodge residue in cavities.

The temporary lighting provided by the contractor inside the enclosure is usually not adequate to conduct a visual inspection, which requires looking closely at the surfaces, trying to discern minute amounts of material that may have low contrast with the substrate. This takes good lighting in two respects: to provide an adequate level of illumination, and to highlight adhering residue. The "drop-light," shown in Fig. 116 is well suited to this purpose, as is a portable, rechargeable halogen light. To perform the inspection for completeness of removal according ASTM E 1368, the project monitor must get close enough to the surface from which the ACM was removed to physically touch the surface and inspect it at close range. This means going everywhere the abatement workers went, even squeezing into tight places (Fig. 117), climbing a scaffold, or riding a powered man-lift (see Chapter 7 regarding safety considerations).

ASTM E 1368 encourages the project monitor to use methods of enhancing the visibility of residue, such as a strong light beam shined parallel to a darkened surface; small particles cast long shadows. The project monitor ". . . may concentrate dust by wiping a clean cloth or glove across a surface to collect evidence of residue" and ". . . use a filter cassette and sampling pump as a small vacuum cleaner to collect visible residue as evidence of unremoved material." Doing so is a way of indirectly inspecting the surface by visually examining the cloth or the filter on which the residue has been concentrated. These wiping and vacuuming techniques resemble those in ASTM D 6480 and D 5755, respectively, for surface sampling. However, the purpose of using them during visual inspection is to collect visible evidence of residue, not to collect samples for analysis. ASTM E 1368 makes it very clear that no samples of residue will be analyzed for asbestos content to determine if the area passes or fails.

Sometimes it isn't very hard to find ACM that should have been removed but wasn't. ASTM E 1368 has a definition for *unremoved material:* any material that was required to be removed by a response action but remains substantially undisturbed. This is ACM that someone simply overlooked or decided was too much trouble to get to. The following example shows what can happen when unremoved material remains after the abatement project is over.

Abatement was performed in a high-rise office building in 1988 to remove fireproofing on beams and the deck. The project design drawing showed a shaded area that included part of one floor and a note required removal of "accessible" fireproofing in the shaded area. The interpretation of "accessible" was apparently left to the abatement contractor, as the specification did not elaborate on this requirement.

Fig. 116—Using "drop light" for close inspection of beam.

Fig. 117—Inspecting space between I-beam and curtain wall.

The space was renovated again in 1995. The deck and beams were covered with a bluish non-asbestos fireproofing, except for some locations where the original asbestos-containing fireproofing remained.

Figure 118 shows the original fireproofing on the bottom flange of a beam (light area in center) surrounded by the darker replacement fireproofing. How did this happen? Figure 119 was taken in 1995 in another part of the same floor, which was not part of the original abatement project in 1988. It is obvious that an abatement contractor would have to drop the duct to get at the fireproofing on the bottom flange wherever a duct runs under a beam, and neither the drawing nor the specification for the 1988 project said to do that. Figure 120 shows a masonry block chase through which a duct had previously run. That the duct was still in place in 1988 and not removed for access is apparent—note the spatula embedded in the fireproofing. Figure 121 shows the inside of a cavity formed by two parallel beams. No attempt seems to have been made to remove the fireproofing from around the bolts or other places inside this cavity during the abatement project in 1988—this picture was also taken in 1995. It is hard to clean asbestos from around the bolts and nuts, and out of the exposed threads. Inspecting this location means getting up on a ladder for a close look. The same is true for any location above eye level, such as the space between the masonry blocks and bottom of the flange in Fig. 122 (again, note the spatula). Lest we forget to look for the obvious, we will distinguish between residue and unremoved ACM for the remainder of this section.

The contractor's competent person must accompany the project monitor and provide at least one worker to perform

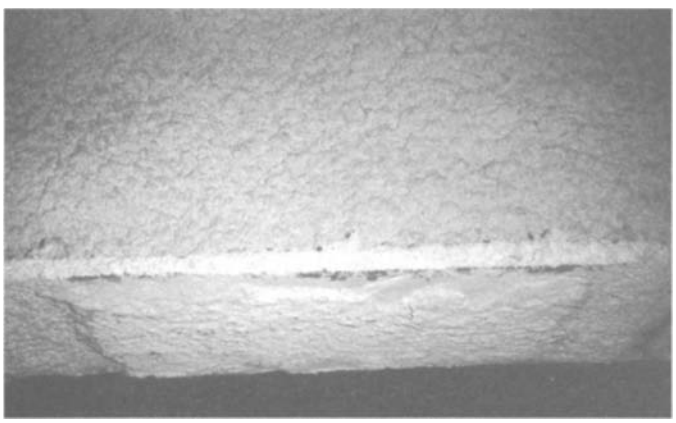

Fig. 118—Original fireproofing on bottom of beam flange.

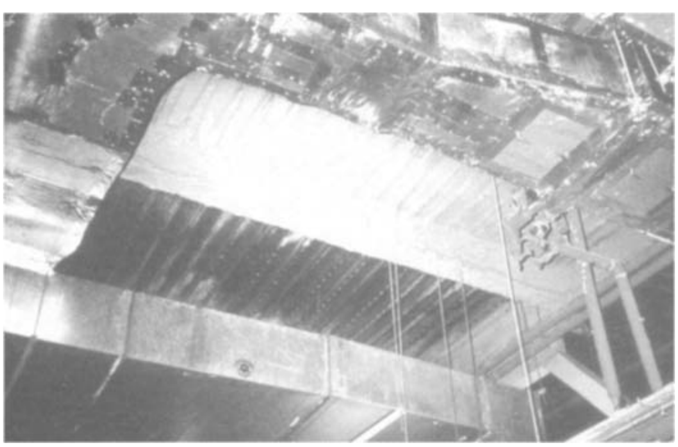

Fig. 119—HVAC duct traversing bottom of beam.

Fig. 120—Original fireproofing remaining in masonry chase.

Fig. 121—Unremoved fireproofing in cavity between adjacent beams.

Fig. 122—Unremoved fireproofing between flange and masonry blocks.

minor cleanup during the inspection. One always finds some amount of residue or unremoved ACM, and the worker(s) can clean small areas or remove small pieces of ACM while the inspection proceeds. If the project monitor finds an excessive amount of residue, he should *terminate the inspection* and direct the contractor to finish removal of the remaining ACM and residue in the area. There is no quantitative criterion for this decision, but if the workers cleaning up the unremoved ACM and residue can't keep up, the area is not ready for the visual inspection. If the inspection continues, it effectively becomes a final cleaning, and ASTM E 1368 says that under no circumstances should the project monitor be placed in a position of supervising a final cleanup. That is the contractor's job. The project monitor should never perform any cleaning out of a desire to be helpful or expedite the inspection! Nor should the supervisor perform the cleaning if doing so will keep the project monitor from maintaining the pace of the inspection.

ASTM E 1368 advises to "Pay special attention to areas that are difficult to reach or see." Use your sense of touch to supplement your visual faculties, particularly in difficult to reach places. If it *feels* dirty, make an extra effort to take a closer look at it. By doing so, you will soon become adept at finding the places the workers missed. To pass the inspection for completeness of removal, there must be no unremoved ACM and no residue remaining on the surfaces. The project monitor should not attempt to distinguish between asbestos material and residue or non-asbestos, with the exception of obvious materials such as cement and paint. Bulk sampling and analysis of residue to determine asbestos content is discouraged.

How clean do we mean? ASTM E 1368 is very direct: "Removal implies that all asbestos-containing material has been removed from the surfaces and components." It does not say: "It's okay to leave a little." Complete removal of the ACM and residue, therefore, is the objective to comply fully with the letter and spirit of ASTM E 1368, so let's look at some examples:

- Figures 123 and 124 show structural steel before and after removal of fireproofing. This is as clean as you can get it, with some credit due to the smooth, painted surface.
- Figure 125 shows a plenum above an acoustical plaster ceiling sprayed on metal lath, where some of the plaster has gone through and coated the joists and deck as overspray. Figure 126 shows this plenum after removal of the ceiling and overspray.

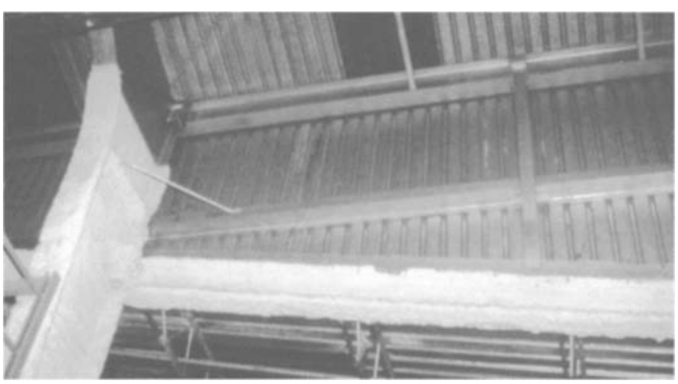

Fig. 123—Structural steel before removal of fireproofing.

- The large tank in Fig. 127 was painted under the insulation; again, the surface was smooth and readily cleanable.
- Figures 128 and 129 show a steam drum and de-aerator from which insulation was removed in a boiler plant. Even though rusted in places, the surfaces have been thoroughly cleaned.

Fig. 124—Structural steel after removal of fireproofing.

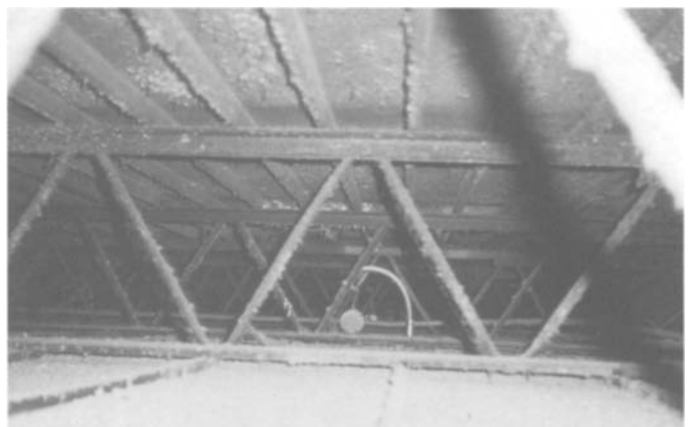

Fig. 125—Overspray from ceiling plaster on joists and deck in plenum.

Fig. 126—Joists and deck after removing plaster ceiling and overspray.

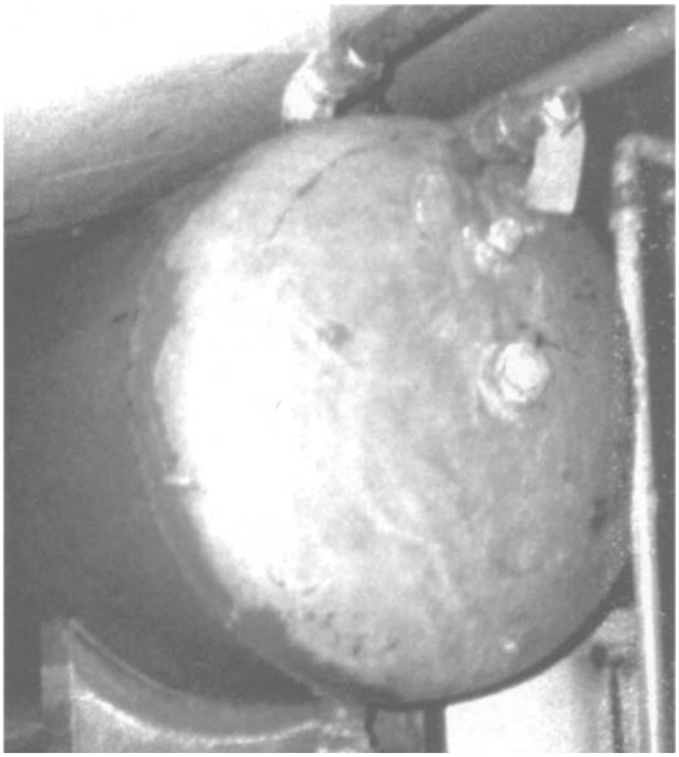

Fig. 127—Painted tank after removal of insulation.

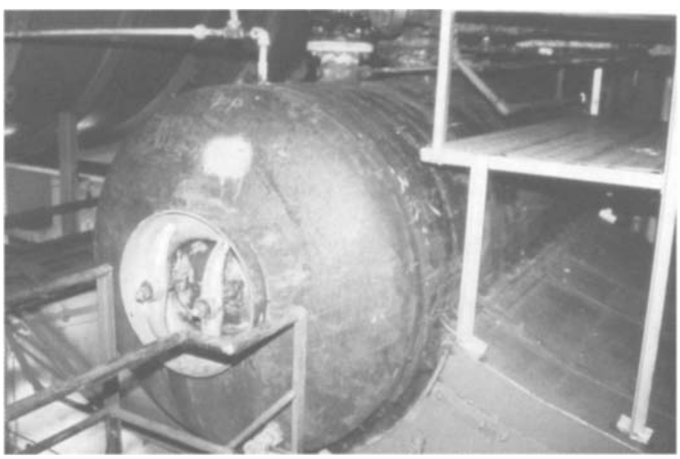

Fig. 128—Steam drum in boiler plant after insulation removal.

"What part of 'No visible residue' don't you understand?"—If the contractor gets the surfaces as clean as was done in these examples, the project monitor's job is much simpler than when there is visible material remaining and the supervisor says "That's as clean as we can get it." Let's first consider two examples where this is patently not true, meaning situations where it is obvious that removal is incomplete and excessive residue remains.

- Figure 130 shows excessive residue on the fittings, while the copper pipe is about as clean as you can get it.
- Figure 131 shows excessive residue on a fluted deck.

Both of these examples were presented as completed abatement and the second one did, in fact, pass someone's visual inspection. These types of situations generally succumb to further application of wetting, scraping, brushing, wiping, and HEPA-vacuuming to pass visual inspection; in other words, old-fashioned elbow grease.

As the foregoing examples show, smooth surfaces are easier to clean than rough ones, and there will be times when the project monitor may have to exercise judgment as to the degree of cleanliness reasonably achievable. Residue can be difficult to remove from surfaces such as corroded steel, grooved scratch-coat ceilings, and adhesive-covered substrates. Visible residue may be readily discernible on some

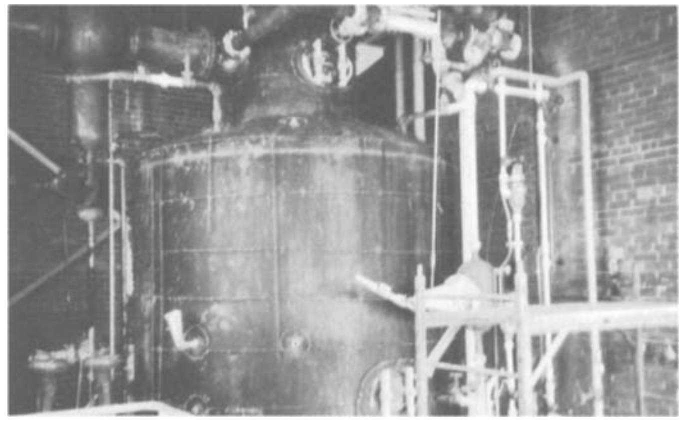

Fig. 129—Boiler plant de-aerator after removal of insulation.

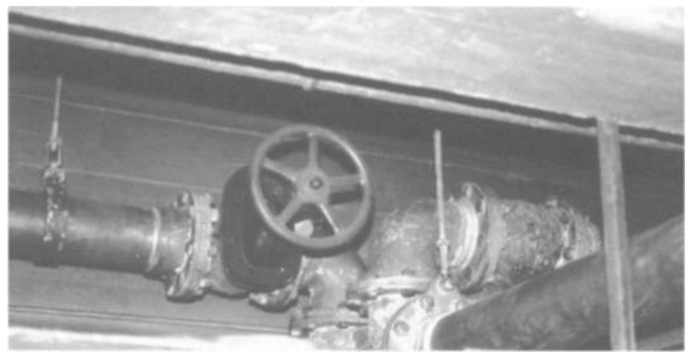

Fig. 130—Excessive residue on pipe fittings and hanger—copper pipe is clean.

Fig. 131—Excessive residue on fluted deck.

surfaces from which the ACM has been removed. If the project monitor feels that the additional cleaning effort would be excessive relative to the amount of residue remaining and that subsequent fiber release can be prevented by a *normal* application of sealer, it is his prerogative to declare the removal acceptable.

On rusted and pitted structural steel, as shown in Fig. 132, the asbestos becomes firmly bonded to the corroded substrate, often to a depth *below* the original surface of the substrate. It is usually so hard that its friability is open to question and it firmly resists removal, even with wire brushing. It may be possible for the project designer to anticipate the situation, because the rust may show through the fireproofing and be noted by an alert project designer during the Project Design Survey (see Figs. 36 and 37, Chapter 2). The existence of such situations, if known in advance, should be identified in the plans and specifications to alert the contractor and project monitor.

Due to similar corrosion, a visible residue may be unremovable from galvanized decking by practical methods, and cementitious, highly adhesive and nonfriable binders may adhere tenaciously to the substrate. If it takes a hammer and chisel to get it off, how much of a fiber release hazard exists from leaving the residue is open to question. In these cases it is acceptable to leave a small amount of visible residue and rely on the sealer to prevent fiber release.

In judging these situations, try to determine the activity to follow abatement and clearance of the area. The importance of absolutely removing all residue is greater for surfaces that will be readily accessible to all building occupants in the condition the contractor leaves it, or a space to be renovated where the surfaces will be accessible to unprotected tradesmen, than if the building is to be demolished and the materials buried in a landfill. If left in place, the residue should be noted in the Daily Project Log and final project documentation, and its location shown on a marked-up abatement drawing. If it will be covered by new acoustical plaster or fireproofing, the re-spray contractor has to be warned against attempting to remove it by sanding, grinding, or chipping.

Although the project monitor has some latitude in judgment when it comes to the removability of residue from certain surfaces, do not cut the contractor any slack if the supervisor pleads that the workers could not get to the material to remove it or properly clean the surfaces. If the project monitor can get in (or up) there and find unremoved ACM or residue, the worker can get in (or up) there to remove and clean it. There may be locations where it is possible to reach or look into that are not sufficiently accessible for removal, such as inside wall cavities. These should be identified during project design, or as soon as possible thereafter, so that decisions can be made and documented as to whether the material will be left in place or other measures, such as demolition, taken to make it accessible for removal.

Fig. 132—Rusted structural steel with unremovable residue.

Once the project monitor determines that the contractor has removed all of the ACM as required by the contract documents, and cleaned the surfaces of all residue reasonably removable by the methods set forth in the specification, the supervisor is informed that the area passes visual inspection for completeness of removal.

Apply Sealer to Substrate or Components

After passing the first visual inspection, the contractor applies sealer to the abated surfaces. The purpose is to bind microscopic fibers too small to be detected during the visual inspection to the substrate. The vernacular for applying sealer is "encapsulating," which is an incorrect use of the word. The definitions of penetrating and bridging encapsulants in ASTM E 1368 (taken from ASTM E 1494) state that both act on an *in situ* (Latin for "in place") asbestos matrix. The residue that remains on a surface after a proper removal and cleaning job hardly qualifies as a "matrix;" there should not be enough left to penetrate or bridge. Therefore, it is not possible to encapsulate a properly abated and cleaned surface. Moreover, the application of a sealer is *not a substitute* for a proper removal and cleaning job, another reason to strongly discourage the use of the words "encapsulate" and "encapsulant" in this context. These terms generally imply an abatement method where the ACM is deliberately left in place, and that obviously is not the purpose of a *removal* project. The owner is paying for and expects *removal*—if *encapsulation* was acceptable the project designer would have specified it. The term "lock-down" is sometimes used to describe the sealer or its application, and this is consistent with ASTM E 1368.

The sealer must be compatible with the intended retrofit, meaning

- It must not compromise the fire rating of re-sprayed fireproofing.
- It must permit acoustical treatments to adhere to the substrate.
- It must withstand environmental conditions such as high or low temperatures and corrosivity in pipe and boiler installations.
- It must not compromise the thermal performance of re-insulation materials.

The sealer should be tinted for visibility to allow the project monitor to expeditiously verify that it is completely applied to the abated surfaces (Fig. 133). Since most sealers are water-based, tinting may be achieved simply by adding latex paint in many cases. The contractor is advised, however, to consult the manufacturer's instructions for assurance that the intended tinting agent will not compromise the retrofit properties listed above. In some cases, there may be aesthetic reasons for preferring a clear (untinted) sealer, and these should be addressed during project design.

Fig. 133—Applying tinted sealer to beam after fireproofing was removed.

Clean and Remove Plastic from Protected Surfaces

ASTM E1368 requires that the project monitor "Conduct another inspection after the sealer has dried to confirm that all surfaces have been completely covered." The contractor then cleans and removes the final layer of plastic sheeting (Fig. 134) and disposes of it. The negative pressure enclosure still exists, as do the critical barriers and decontamination facilities. Once the plastic is removed, the actual building and equipment surfaces that the contractor so diligently protected during preparation are exposed. The thoroughness of these preparations now becomes evident. Do not forget, however, the project monitor's responsibility to oversee those preparations earlier in the project.

Perform Final Cleaning Inside Enclosure

The contractor then performs the final cleaning steps required by the specification, such as wet-wiping the walls (Fig. 135) and wet-mopping the floors. Critical barriers, including the plastic covering windows and doors, remain in place, provided that no debris is trapped behind, beneath, or within the sheets of plastic or duct tape. If there is, the plastic is removed and replaced. After all debris and residue is removed from the walls, floors, and other surfaces, and from all of the nooks and crannies where water is prone to run, the contractor HEPA-vacuums the entire area. Some specifications and regulations require another cleaning after a "settling period" of a specified number of

Fig. 134—Cleaning and taking up floor plastic.

Fig. 135—Wiping walls after plastic is removed.

hours, during which airborne fibers theoretically settle gently to the floor to be removed during the second cleaning. In practice, they follow the air currents and are either removed by the negative air machines or they adhere to any surfaces they impact. After the contractor gets the area as clean as the supervisor thinks is possible, the project monitor conducts the second inspection, for completeness of cleanup.

Inspect for Completeness of Clean up

During this inspection, the contractor provides the same assistance to the project monitor as during the inspection for completeness of removal. This means furnishing ladders, scaffolds or powered man-lifts as well as workers with cleaning materials. The project monitor should have the same tools and lights that were used during the first inspection.

All contaminated material, including bags of waste and removed plastic, must have been taken out of the enclosure before starting this inspection. The only equipment remaining inside the enclosure should be the negative air machines and any ladders, scaffolds, powered man-lifts and lights needed for the inspection, and these must be clean. The decontamination and load-out facilities are still in operation and must be clean.

The project monitor uses methods similar to those employed during the inspection for completeness of removal to detect any debris remaining inside the enclosure. This means an inspection of all surfaces, except the abated surfaces that have been covered with sealer and previously inspected. ASTM E 1368 recommends inspection at close range with a strong light in a darkened room, looking across horizontal surfaces from as close as you can get to them, with the light at a right angle to your line of vision so that particles of debris become very visible. One way to assess the cleanliness of the floor is to wear disposable foot coverings and look at the bottom of them after walking around a while. You have been "sampling" the floor and the debris that adheres to the bottom of the "booties" is an indication of its cleanliness. Another way is to get down on your hands and knees with the room darkened and shine the light across the floor. You can also supplement your visual senses with touch: does the surface *feel* clean?

At this point, a careful reading of the Completeness of Clean-up section of ASTM E 1368 in its entirety is suggested, as well as going back over the sections of this *Manual*

covering the inspections during preparation and removal. If the precautions for those phases of activity were not faithfully executed, the consequences will become evident during the visual inspection for completeness of cleanup. Remember that you are looking for debris that fell from above or was carried by water—the airborne fibers that have settled out cannot be seen. A few of the locations where you are likely to find debris during this inspection include:

- Items attached to walls that had been covered with plastic, such as electrical panels and HVAC grills, can trap debris behind or inside them. Trim strips for lay-in ceiling grids, if left up, are notorious for this, as are cove base moldings.
- The intersection of horizontal and vertical surfaces, such as walls and floors, tend to accumulate debris.
- Check the walls and other vertical surfaces for debris and water streaks, as shown in Figs. 136 and 137.
- Look *into and under* all items of equipment and furnishings that had been covered with plastic, such as the fan coil units shown earlier in Fig. 84. It may be necessary to remove panels, open doors, or partly disassemble things to get to where the water may have run;
- Check floor troughs, cable runs, and floor penetrations for water and debris;
- Look under any loosened floor tiles, such as those shown in Fig. 138 for debris.

Fig. 136—Pipe insulation debris on brick wall.

Fig. 137—Debris on wall and conduit not properly protected by plastic.

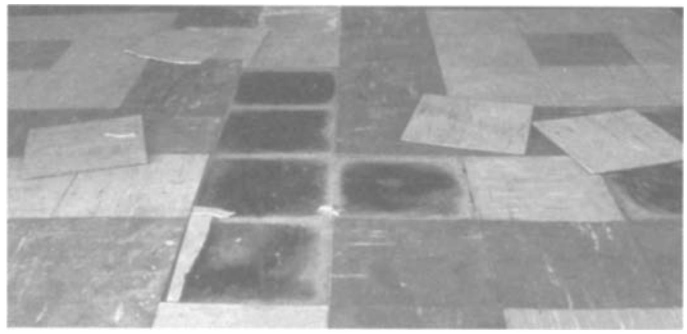

Fig. 138—Debris under floor tile loosened by water that leaked through plastic.

Check the bottom of critical barriers, and also look on the other side of the barriers in adjacent spaces for debris that might have run underneath. Figure 139 shows a very poorly protected door where water and debris have leaked outside the building.

If carpeting has been left in the enclosure, was not adequately protected, and the floor plastic leaked, it will be wet and contaminated, as in Fig. 140. ASTM E 1368 discourages taking final air samples unless the carpet is dry; as a room with wet carpeting can pass clearance testing, then fail another test after it dries out. Visible debris is clear evidence of contamination and a wet carpet should be considered presumptive evidence of the same. The choices are to:

- Remove the carpeting and dispose of it as contaminated material, which may be the quickest alternative;
- Steam-clean it and decontaminate the cleaning equipment, which would be the next fastest option;
- Wait for it to dry and then HEPA-vacuum it. This is the slowest option, due to the high humidity level in the enclosure.

Which option is more expensive is arguable, since "time is money" on an abatement project. If the carpeting stays wet for several days, there is a risk of mold and mildew appearing. Besides causing irreversible damage to the carpet, the mere presence of mold and mildew might be of great concern to the owner and occupants. To alleviate anxiety over possible health effects from the mold and mildew, the owner may insist on a mold remediation project after abatement is completed, at the expense of the abatement contractor.

Fig. 139—Water and debris leaked through critical barrier to outside of building.

Fig. 140—Carpet is wet and contaminated due to leak in floor plastic.

The above examples are by no means exhaustive. Other critical areas for inspection will depend on the type of ACM being removed, the details of the project, and the building characteristics. The more widely distributed the ACM is throughout the removal area, as in the case of acoustical plaster on an entire ceiling or fireproofing across an entire deck, the more widespread debris is likely to be found. In this case, all surfaces inside the enclosure must be closely inspected. If the ACM is confined to fireproofing on perimeter beams or pipes along a wall, it is possible to limit debris and contamination to those areas. Concentrate the inspection accordingly, not ignoring a responsibility to inspect the entire enclosure for completeness of cleanup. If the contractor has been careless about tracking debris around the enclosure or has not controlled water and debris, then the entire enclosure demands a very thorough inspection.

ASTM E 1368 states "No unremoved material, residue, dust, or debris should be visually detectable on the visual inspection for completeness of cleanup." The question always comes up regarding debris that the contractor contends is not asbestos. ASTM E 1368 makes no exception: it must be cleaned up, and the rationale that the presence of *any* visible debris in previously or possibly contaminated areas signals the presence of asbestos fibers is hard to refute. If there is any dirt, then the area was not properly cleaned and, *ipso facto*, there is asbestos present as well. The only exception to this rule might be in areas where an obvious source of non-asbestos debris (such as crumbling mortar) is present, there was no ACM removed in the vicinity and no evidence of water or other sources of asbestos debris. Such cases must be scrutinized individually and carefully, and if any doubt exists, the debris must be cleaned up.

If the area does not pass this inspection, it must be recleaned. The same rationale regarding termination of the inspection that was used for the inspection for completeness of removal applies here. The project monitor will find residue and debris, and the workers should be permitted to clean up minor amounts as it is pointed out to the supervisor. As with the inspection for completeness of removal, if the workers cannot match the pace of the inspection with their clean-up efforts, terminate the inspection and direct the contractor to re-clean the area. Such a pattern may be revealed early in the inspection, or it may reflect an abrupt change in the difficulty of the clean up because of the equipment and building characteristics, or it may result from different degrees of thoroughness among the workers in various parts of the enclosure. Whatever the reason, the project monitor is not supposed to supervise the final cleanup: that is the contractor's job.

At this point the area should be as clean as it ever has been, and as clean as it ever will be. Before the abatement project, no one cleaned the building with a HEPA-filtered vacuum cleaner. After it is over, no one will ever do so again.

Perform Air Sampling and Analysis for Clearance

After the area passes the inspection for completeness of clean up, final air samples are taken for clearance following a "settling" period (see ***Clearance Samples—When to Start the Pumps***). Sidebar 6. Aggressive methods, where the

Sidebar 6—Clearance Samples—When to Start the Pumps

It is customary to require a "settling period" or "scavenging period" to elapse between the final cleaning and taking clearance air samples. However, requiring that no activity takes place inside the enclosure during this time unnecessarily delays completion of the work. The inspection for completeness of clean up, followed by setting up the pumps and fans, should take place during this period. Although the "scavenging" of the air during this time helps the area pass the final air clearance, it is much more important to have thoroughly cleaned the abated surfaces and all areas inside the enclosure. If the schedule permits, an overnight scavenging period before the visual inspection for completeness of cleanup or the final air sampling doesn't hurt. However, failure of the area to pass final clearance will be due to the fibers re-entrained by the aggressive air sampling, not those that failed to "settle out" or escape during the scavenging period.

How long should the enclosure be ventilated before final air samples are taken? Some specifications and regulations call for a 24-h settling period while others insist on 96 air changes. Some simple calculations show that this is over-doing it.

The time, t, to reduce the concentration of an airborne substance by ventilation is given by

$$t = \frac{1}{Q/V} \ln(C_0/C_t)$$

Q/V is the number of air changes per hour—the output of the negative air machines in cubic feet per hour divided by the room volume in cubic feet. C_0 is the initial concentration and C_t is the concentration at time t.

If we start with an enclosure where C_0 equals the OSHA Permissible Exposure Limit of 0.1 fiber/cc and we want C_t to equal a clearance level of 0.01 fibers/cc, the 90% reduction in fiber levels will be achieved in 35 min at four air changes per hour. Add a factor of safety to get a 99% reduction and it will take 1 h and 10 min.

Sidebar 6—Clearance Samples—When to Start the Pumps—*continued*

- This calculation makes two important assumptions:
- The air inside the enclosure is well mixed and the concentration is uniform throughout the space. In practice, there will be dead spots with little air movement from which fibers are scavenged at a much lower rate.
- No additional fibers become airborne inside the enclosure or enter with the make-up air. Any activity—including the inspection for completeness of cleanup and setting up the sampling pumps—during this time invalidates this assumption.

The amount of time to wait before turning the pumps on depends on the conditions inside the enclosure that the project monitor observed during the course of the work and the results of the visual inspections. If the area failed these inspections, if high fiber levels have been measured or other concerns about the ability to pass the clearance sampling exist, it may be prudent to wait for a scavenging period much longer than that indicated by the above equation to elapse. ◆

surfaces inside the enclosure are physically disturbed, are used.[5] "Passive" air sampling, where surfaces inside the enclosure are not disturbed while the pumps are running, is discouraged unless there are compelling reasons peculiar to a specific project. If exposed ACM remains inside the enclosure as a result of a partial removal, it should be protected against fiber release during aggressive air sampling by methods discussed in the next chapter.

ASTM E 1368 says that

> "Aggressive sampling should be conducted, with the surfaces agitated by sweeping or brushing, by fans used to circulate the air, or by electric leaf-blowers directed at the surfaces (see EPA 560/5-85-024, Appendix M)."

The parenthetical reference is to the well-known guidance document called the "Purple Book" that was published in 1985 [6]. The requirements in Appendix M were incorporated almost *verbatim* in Appendix A, Section IIIB of the AHERA regulations and many state regulations. ASTM E 1368 does not go into detail as to how aggressive air sampling should be done, and therefore some elaboration is in order.

Fig. 141—Box fans and high-volume pump used for clearance sampling.

Electric fans are used to circulate air in the enclosure so the filters collect a "representative" sample of airborne fibers. Common practice is to put one fan with each air-sampling pump or use one fan per 10,000 ft^3 (283 m^3) of room volume. A 20-in. box fan (Fig. 141) will produce an air velocity of 150–200 ft/min (0.75–1.00 m/sec) at a distance of 30 ft (9 m), which is sufficient to keep the air moving in most abated spaces. For cavernous rooms like the warehouse shown in Fig. 142, it would not be unreasonable to use larger fans.

There is more to aggressive air sampling than air circulation, and that is where the leaf blower comes in. The Purple Book calls for a one-horsepower electric leaf blower, which will deliver 75 ft^3/min (2.12 m^3/min) of air at a velocity of 4500 ft/min (22.86 m/sec) at the exit of the duct. The force of this airstream is enough to entrain loose debris and release fibers that are not too tenaciously attached to a surface. The Purple Book directs you to sweep the exhaust over surfaces at a rate of 1000 ft^2 (93 m^2) per minute, but there is no prohibition against using the leaf blower for as much of the sampling time as you are willing to carry it around. Rather than concentrate on the smooth surfaces that were easy to clean, direct the exhaust at the corners and crevices where debris collects and may not have been cleaned (Fig. 143). Of course, the leaf blower has to be held close to the surface to be effective (Fig. 144).

There is also an element of fairness to using a leaf blower. By directing the exhaust at obvious sources on non-

Fig. 142—Large spaces such as this warehouse require more air circulation.

[5] There are two schools of thought on aggressive air sampling, which evolved about the same time as the concept of visual inspection in the mid-1980s. One contingent maintains that aggressive air sampling should simulate the disturbance of fibers that will occur after the area is cleared. The other faction wants to maximize the number of fibers captured by the air sampling filters.

Fig. 143—Directing leaf blower exhaust at corner of wall and floor.

Fig. 144—Using leaf blower on beams near warehouse deck.

asbestos fibers, such as fiberglass insulation, it would be very easy to fail an area if Phase Contrast Microscopy was being used to analyze the filters. It is obviously unwise to stir up so much dust from construction debris that the filters are unreadable.

Aggressive air sampling is not limited to using leaf blowers. Figure 145 shows a brush being used to disturb the pipes. Shaking the pipes will release loose residue in the hangers and elsewhere. If such physical methods of aggressive air sampling are going to be used, make sure the specification doesn't limit the project monitor to using a leaf blower, which is all that most contractors expect.

The procedure to be followed if visible debris is generated by aggressive air sampling should be covered in the specification. One approach is to simply terminate the air sampling and require the contractor to re-clean the area. If the amount of debris generated is small, the project monitor may allow the contractor to clean up the debris, using wet methods, and continue with the air sampling. If this is done, both parties must recognize that the chances for passing are diminished by the generation of the debris before the cleaning operations.

If visible debris is produced during aggressive air sampling, it raises the question of how thorough the visual

Fig. 145—Aggressive air sampling using brush to disturb pipes.

inspections and associated cleaning were. Of course, visible debris need not be produced for aggressive air sampling to cause the area to fail clearance. If the area fails to pass for any reason, it must be re-cleaned, the inspection for completeness of cleanup repeated, and air sampling performed again. The contractual implications of not passing the air sampling for final clearance, such as who pays for additional inspection, sampling and analysis, and also the possible imposition of liquidated damages for delayed completion of the work, must be clearly spelled out.

Many fibers that could be entrained during aggressive air sampling are not visible to the naked eye and could not have been seen during the visual inspections. Therefore, it is important to note in the specification that passing the visual inspections is *not* an assurance that the area will pass final air sampling. Areas have passed visual inspection and then failed final air sampling, and visibly dirty areas have passed final air sampling. The specification should avoid statements that imply any sort of warranty to the effect that, if an area passes the visual inspections, the final air sampling results will be acceptable to release the area, and the consultant should not contractually accept liability for failure of the area to pass.

The specifics of final air sampling are outside the scope of ASTM E 1368 but some issues bear discussion here. First, the specification is not the place for the details of air sampling such as flow rates and volumes for any samples taken by the consultant. The specification is part of the building owner's contract with the abatement contractor, and the latter has no control over air sampling except for OSHA compliance. All other air sampling is done by the project monitor and should be defined in the consultant's contract with the building owner.

This is not to say that the specification should be silent on the subject, as the contractor needs to know the basis for accepting the work. The specification should state the method of analysis of the final air samples—Phase Contrast

Microscopy (PCM) or Transmission Electron Microscopy (TEM)—and the criterion for passing. Usually this is an airborne concentration in fibers/cm^3 of air for PCM and structures per mm^2 of filter surface for TEM. It must be clear whether the criterion for passing is the average of the samples collected or if all samples have to be below the specified limit.

It is important for the consultant to retain some flexibility in how the final air sampling is conducted, AHERA regulations for schools and some state regulations notwithstanding. There is nothing sacred about taking five air samples for clearance. More or fewer may be needed depending on the size of the enclosure, which may not be known until it is built. For the large enclosure in Fig. 142, six samples were taken and all had to pass, which the contractor 's supervisor was told well before the samples were taken.

Some consultants fall into the trap of simply referencing the "AHERA protocol" for clearance sampling in situations where they are not required to use it. One consultant did so with the intention that all five TEM samples had to pass in order to clear an area but did not explicitly say so. This criterion is not unheard of—it is in the Missouri regulations [7] but the project was in another state. After the consultant failed some areas on the basis of the intended criterion, the contractor insisted that five air samples be taken outside the enclosures and clearance based on the AHERA "Z-test." Along with other problems on this project, the clearance criterion was one of the issues in the ensuing litigation. The message for consultants is to be *very* clear in the specification as to what the criterion is for passing the final clearance sampling.

Dismantle Critical Barriers and Decontamination Facilities

Following successful final air sampling, the negative air machines are turned off and the critical barriers and decontamination facilities are dismantled. A final inspection is then conducted for debris that may have been concealed by the barriers themselves. Any debris discovered during this operation should be cleaned up using O&M procedures for a fiber release episode (see Chapter 6). The specification should state whether additional air samples are needed after the clean up.

The area is now ready to be turned over to the general contractor for renovation (Fig. 146) or to the owner for re-occupancy (Fig. 147).

Fig. 146—Small room after completion of abatement is ready for renovation.

Fig. 147—Warehouse after completion of abatement can be returned to service.

Documentation and Certificate of Completion

The documentation requirements in ASTM E1368 are shown in Table 7. It is not unusual for a large abatement project to generate a stack of paper a foot thick. Much of it is required by regulations, and the contract should spell out who is responsible for keeping what types of records.

From the project logs maintained by the contractor and project monitor on these projects, it is possible to visualize the project developing and, if things went wrong, get a sense of when and why the wheels came off. Do not be surprised when the contractor's and project monitor's versions of the same day's events do not coincide. As noted in ***Unexpected Situations***, it is the paper trail that matters if claims are filed and litigation results.

For the contractor, the paper trail ends with getting paid for the work and two of the most important documents leading to approval of a pay application are the waste manifest and the Certificate of Completion. The consultant should not sign the pay application until all of the waste manifests are back from the landfill and the numbers agree with the project monitor's records.

Sometimes called the Certificate of Substantial Completion because the contractor is still responsible for coming back and fixing minor problems, this form is where the consultant attests in writing that the contract requirements have been met and that the area can be occupied by unprotected persons. It states that the areas passed the visual inspections and final air sampling. It records any approved deviations from the scope of work and identifies ACM intentionally left in place. There is little else that the Certificate needs to say, but some consultants effusively include statements in the Certificate such as

- The building is free of asbestos
- The area is safe to re-occupy
- All asbestos has been removed
- All regulations were complied with

These statements imply a more comprehensive, if not absolute, degree of abatement and compliance than one can possibly achieve and the liability implications are obvious. In one of the ASTM *Standards for Asbestos Control* courses, I posed a question to a lawyer in the audience. "Mr. (Lawyer)," I said, "if I signed a certificate with statements like these, and

Table 7—Documentation for asbestos abatement project.

Project Phase	Documentation	Prepared by
Project design	Project Design Survey report (if required)	Accredited inspector and project designer*
	Plans and specifications	Project designer
Bid solicitation	Bid package including contract and addenda	Consultant
	Pre-Bid Conference notes	Consultant
	Proposals from bidders	Abatement contractors
	Evaluation and references	Consultant
	Executed contract	Owner and contractor
Construction period	Pre-Construction meeting notes including Differing Site Conditions	Consultant and project monitor*
	Contractor's daily logs and air monitoring data (OSHA compliance)	Contractor's supervisor
	Project monitor's daily logs and air monitoring data (including final clearance)	Project monitor
	Record of visual inspection(s) for completeness of preparations	Project monitor
	Record of visual inspection(s) for completeness of removal	Project monitor
	Record of visual inspection(s) for completeness of clean-up	Project monitor
	Waste disposal records and signed manifests	Contractor's supervisor and project monitor
	Certificate of completion for project or each phase	Consultant
	Pay application(s) for project or progress payments	Abatement contractor
	Approved pay application(s)	Consultant

* These may be the same person.

you got me on the witness stand, what would you do to me?" His reply: "I would torture you."

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[5] Vermont Regulations for Asbestos Control, V.S.A.Title 18, Chapter 26, Vermont Department of Health, Burlington, VT. Amended November 1995.

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5 Abatement Projects—Beyond the Basic Ceiling Scrape

CHAPTER 4 PROVIDED A DETAILED INTRODUCTION to using ASTM E 1368 and the visual inspection process for asbestos abatement under "gross removal" conditions, which are typical abatement projects. There are, however, numerous projects involving more than these basic removal techniques. This chapter describes the use of E 1368 and visual inspection for applications that go beyond the "basic ceiling scrape."

The examples in Chapter 4 involved *friable* surfacing materials and thermal system insulation. This chapter discusses friable and *nonfriable* miscellaneous material, as well as more abatement techniques for surfacing materials and thermal system insulation.

Discussion of nonfriable ACM in ASTM E 1368 is limited to the brief but important statement in Section 5. Significance and Use:

> "This practice applies to response actions for all types of asbestos-containing materials, including surfacing materials, thermal systems insulation, and miscellaneous materials, *whether friable or not*, regardless of the quantities involved and the reason for conducting the response action" (*emphasis added*).

The AHERA regulations don't even consider abatement of nonfriable ACM in schools to be a response action. However, a considerable amount of effort goes into sampling, analyzing, and abating floor tile and mastic, roofing materials, and other nonfriable ACM, which is why they are included in the definition of *response action* in ASTM E 1368. To a large extent, nonfriables have become their own special category of asbestos control.

We can—and should—apply the visual inspection process and ASTM E 1368 to the management of nonfriable materials, because these materials can be handled in such a way that airborne fibers are generated [1,2]. Not as easy, perhaps, as it is with friable materials, but it happens. We can follow the same basic procedures that apply to friable materials, modified as explained in this chapter.

The NESHAP defines *nonfriable asbestos-containing material* as that which *cannot* be crumbled to powder by hand pressure. In Category I nonfriable ACM this regulation includes packings, gaskets, resilient floor covering and asphalt roofing products, while Category II includes all other nonfriable ACM. The distinction between friable and nonfriable ACM forms the basis for many important regulatory distinctions that usually include exemptions from some provisions of the regulations for nonfriable materials, providing that the material remains nonfriable during removal or other work. If fiber release occurs, it must be handled as friable material. The safest approach is to treat it as if fiber release will occur.

The effectiveness of water to control fiber release is reduced by the inability of the water to penetrate nonfriable material, even with a surfactant. Water can adhere to the material and inhibit fiber release from the surface, but if the material is broken, fibers can escape from the dry interior. Thus, keeping the ACM intact is a key to reducing fiber release. Fortunately, nonfriable materials, by their very definition, have greater strength than friable ACM and are more capable of remaining intact. See Chapter 3 for a discussion of what "intact" means in a regulatory sense.

Floor Coverings

While it is generally true that resilient floor coverings are nonfriable, we will have occasion to question the blind acceptance of that statement. The types of floor coverings we will discuss include the more prevalent floor tile, commonly called vinyl asbestos tile or simply VAT, and sheet vinyl flooring—commonly called "linoleum."

Resilient floor tile

An estimated 2.7 billion ft^2 (250 million m^2) of asbestos-containing floor tile has been installed in 1.5 million buildings in the U.S., according to an EPA study published some years ago [3]. That is almost 100 square miles of floor tile, or enough to cover the city of Jackson, MS.

Chapter 2 offered suggestions on sampling floor tile and mastic, and also discussed some analytical issues. Floor tile and mastic should be approached as a floor covering system for abatement purposes if one or both contain asbestos. Non-asbestos floor tile held down with asbestos-containing mastic—usually black asphalt-based material—must be treated as ACM for removal purposes because of the mastic that sticks to the bottom of the tile.

Floor tile is unquestionably nonfriable, but what about the mastic? Mastic scraped off of a tile or slab and allowed to dry can be crumbled in the hand, and for that reason it should be treated as friable. If a concrete slab is broken up during demolition, the dry mastic will release fibers, which contravenes the conventional wisdom and some regulatory interpretations that permit leaving asbestos floor tile and mastic in a building that is being demolished.

Figure 148 was taken in a building where 100 000 ft^2 (9290 m^2) of asbestos floor tile was removed but the asbestos-containing asphalt mastic was left. The owner was unsure if he was going to renovate or demolish the building—if it was renovated the flooring contractor would probably have taken a sander to the entire floor. Large areas had

Fig. 148—Large areas of asbestos-containing asphalt mastic were left in this building.

Fig. 150—Plastic "splash guard" on wall for tile removal project.

mastic over leveling compound as shown in Fig. 149. Imagine the dust cloud with asbestos fibers attached to particles of friable leveling compound that would have been created by sanding the slab.

Floor tile involves steps of preparation, removal and clean up similar to those in Chapter 4, with a few differences.

Preparation—The contractor obviously doesn't cover a floor from which the tile is going to be removed. However, the project monitor should look carefully for penetrations in the floor through which water could leak and make sure they are sealed. Wood floors in older buildings present problems of water leakage into the floor below in addition to the air infiltration discussed in Chapter 4. It may be necessary to seal these leakage paths from below in such cases.

The minimum protection of walls should be a "splash guard" at least five feet (1.5 m) high that is securely taped across the top (Fig. 150). This will suffice for most manual removal projects as water and debris will not hit the wall any higher. If it does, or if more aggressive mechanical removal methods can contaminate the entire wall, then it should be covered to the ceiling.

Removal—Manual removal of floor tile usually consists of scraping it off a concrete slab with spud bars (Fig. 151). Sometimes the tile is on a plywood underlayment and the preferred method is to remove the plywood sheets with the tile attached (Fig. 152). The plywood and tile are wrapped in plastic sheeting for disposal. There may also be more than one layer of tile, as in Fig. 153.

Mastic isn't the only asbestos-containing substance found under floor tile. Asphalt paper vapor barriers contain asbestos and must be scraped off by hand or mechanically removed (Fig. 154). What about carpet on asbestos floor tile or on tile with asbestos mastic? The carpet sometimes sticks to the tile tightly enough to pull the tile up with it, in which case both must be removed under abatement conditions and disposed of as asbestos waste.

The inspection for completeness of removal may find some unremoved tile, but it is more likely to find mastic residue. When deciding how much residue is permissible to leave, find out what is going to happen to the floor after the area is cleared. A flooring contractor is likely to sand or grind it to prepare the surface for the new floor. In this case, "no visible residue" remains the criterion for passing the inspection. Apply the "chisel test" (Fig. 155). If the residue is thick enough to scrape off with a sharp chisel blade, it is too thick and must be removed for the area to pass. Brown asphalt stains pass the "chisel test" but otherwise the surface must be smooth to the touch.

Fig. 149—Leveling compound (white) under mastic.

Fig. 151—Worker removing vinyl asbestos floor tile.

Fig. 152—Tile attached to plywood underlayment.

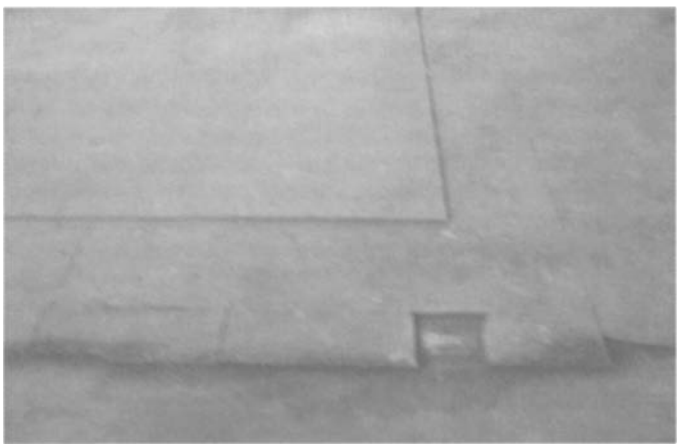

Fig. 153—Two layer of floor on tile concrete slab.

The consequences of incomplete mastic removal can be subtle but severe. A retail space contained 12 × 12 in. tile that the owner said was only four years old, and sure enough the tile did not contain asbestos. Neither did the brown mastic, but a couple of tiny spots of black mastic had 5% chrysotile. This was obviously the result of a not-quite-complete abatement job before the new tile was installed. Because of that, the state inspector ruled that all of the new tile would have to be taken up under full abatement conditions. The owner elected to cover it instead, which is what many people do when they find they have asbestos floor tile and/or mastic. If the flooring contractor will put a new floor down over the asbestos floor tile—and some won't—leave the asbestos floor tile alone. Just don't forget it's there.

Sheet vinyl flooring

Linoleum is resilient floor covering, which the NESHAP defines as Category I non friable ACM; *ergo*, linoleum is non-friable, right? The woven or matted backing (Fig. 156) has a high percentage of chrysotile and is very friable unless saturated with adhesive. How saturated isn't known until it comes up, so treat it as a friable material. It is not unusual to find two layers of linoleum, and linoleum on top of floor tile is also common.

The backing must be kept wet while the linoleum is being rolled back, exposing small amounts of backing at a time. Some of the backing will stick to the slab and must be wetted

Fig. 154—Removing asbestos paper vapor barrier.

Fig. 155—"Chisel test" for excessive mastic residue.

and scraped off. The "no visible residue" criterion applies just as for any other ACM that is stuck to the substrate.

Other Miscellaneous Materials

Two types of miscellaneous materials deserve special attention because of their properties and frequency with which

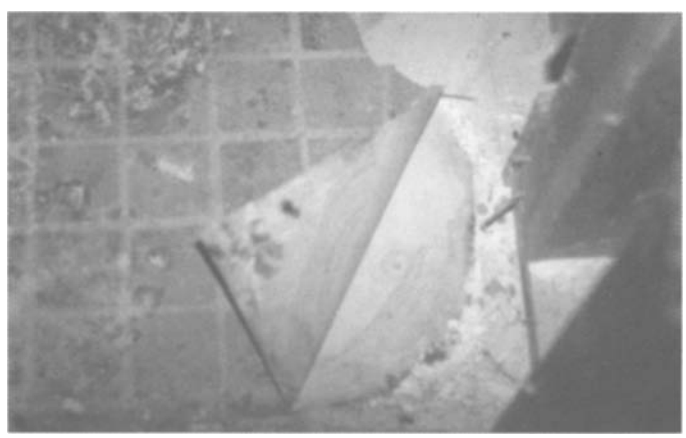

Fig. 156—Sheet vinyl flooring has friable asbestos backing.

they occur—wallboard joint compound and asbestos-cement products.

Wallboard Joint Compound

Probably no other construction material has caused as much confusion as wallboard joint compound, and disagreements exist even among the regulators. What people refer to as wallboard joint compound is actually three different materials that are part of a "wallboard system."

When sheets of wallboard—a gypsum core covered with paper facing—are installed, the gaps between them are filled with a compound that hardens in place. The joint is then covered with a thin strip of paper that is held in place by a troweled-on adhesive. This process is called "tape and float" and is what gives the wall its smooth appearance after it is painted or papered. The same material used to cover the tape is often used to cover nail holes and other imperfections in the surface of the wallboard, and is sometimes called a "skim coat." Figure 157 shows a wall with the skim coat over the joints and nail holes.

Asbestos is found in all of these products—the joint compound, the tape and the skim coat. It is rarely found in the core or facing materials. The use of asbestos in "sealant tape" and "textile products" was never banned in the U.S., and EPA has also stated that they have not banned "troweled-on Surfacing ACM" [4]. Because the joint compound and skim coat are applied with a trowel, one might consider them "troweled-on Surfacing ACM." But are they "Surfacing ACM?" Even though the AHERA and OSHA definitions of surfacing material both include the words "troweled-on," an OSHA interpretation posted on their website specifically states that joint compound is not surfacing material [5]. This interpretation goes on to say that removal of wallboard systems is Class II work, and wallboard joint compound is part of the wallboard system. It is not Class I work because the joint compound is not considered surfacing material by OSHA.

Like OSHA, EPA speaks of a wallboard system. Where the agencies disagree is on the issue of "compositing" bulk sample results. EPA requires that each individual layer of a sample—which could include the joint compound, tape, skim coat, paper facing, gypsum core, paint, plaster, wallpaper, etc.—be analyzed separately and results reported for each layer [6]. However, they allow the compositing of the results in determining whether the sample as a whole contains more than one percent asbestos. If not, the material isn't regulated, and the opportunity presents itself to manipulate the relative amount of the different layers in the sample to avoid regulation. OSHA sees it differently. They do not allow compositing of sample results from different layers of a wallboard system [7]. If any one layer contains more than one percent asbestos, removal of the wallboard system is regulated as Class II work because the potential exists for exceeding the Permissible Exposure Limits.

What about the finish on the wallboard itself? A thin coat of paint that contains asbestos is not surfacing material according to OSHA and its removal is still Class II work, but a thicker textured paint would be surfacing material and removal becomes Class I [8]. Wallboard is often used as the substrate for the spray-applied textured material on ceilings referred to as "popcorn finish." Removing this finish or the wallboard system it is applied to is definitely Class I work. In abating a room, it is wise to look at all the materials to be removed and use the controls that apply to the most stringently regulated ones.

State regulators may have their own interpretations. I recently found asbestos-containing skim coat over the wallboard joints in a section of a hospital constructed in 1991. When I asked the state regulator if abatement for renovation could be limited to stripping out the wallboard a few inches on either side of the joints, he replied that the entire wallboard had to be removed as ACM because the same skim coat might have been used to cover the nail holes.

Asbestos-Cement Products

The asbestos control community in the U.S. concentrates on friable surfacing material and thermal system insulation, as well as nonfriable floor tile, without realizing that these are not the dominant forms of ACM in most of the world. According to the trade association for asbestos producers: "Chrysotile cement represents between 85% and 90% of the market for chrysotile asbestos . . ." [9].

Even in the U.S., certain types of asbestos-cement products are familiar. It is the siding on your house or your neighbor's (Fig. 158) and the cooling tower in Fig. 55 of Chapter 3 is made from it. A lot of it is unseen: the buried pipes that carry drinking water and the electrical ducts under the street. The name "Transite™" that is often applied to

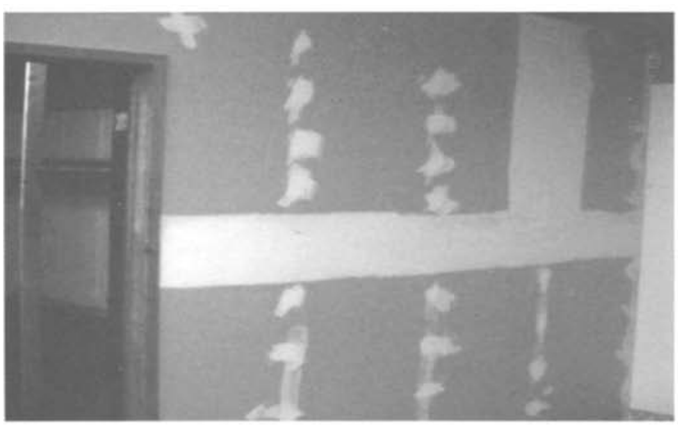

Fig. 157—Skim coat over wallboard joints and nail holes.

Fig. 158—Asbestos-cement siding on houses.

asbestos-cement materials is actually a trademark for products with a specific formulation of 15–25% chrysotile, 25–35% silica flour and 45–55% Portland cement [10]. Figure 159 shows an exhaust flue marked as "Transite."

In other countries, asbestos-cement products are ubiquitous. It is not surprising that the building in Fig. 160 has asbestos-cement roofing and siding, as it is part of the plant in Israel that also made the asbestos-cement pipe in the foreground. Not only is it used for pipe and building materials in that country (and others), the waste from the manufacturing process was used for pavement (Fig. 161). Even lawn furniture was made from asbestos-cement.

The installation of new asbestos-cement products continues worldwide and it is to that market the quotation in the first paragraph refers. The corrugated asbestos-cement roof in Brazil (Fig. 162) was replaced in 2000 with a new one—also made of asbestos-cement (Fig. 163).

For abatement of asbestos-cement products, the following techniques should be followed:

- The surface of the material should be kept wet with water containing a surfactant (amended water) during all removal activities, such as removal of the siding shown in Fig. 164.

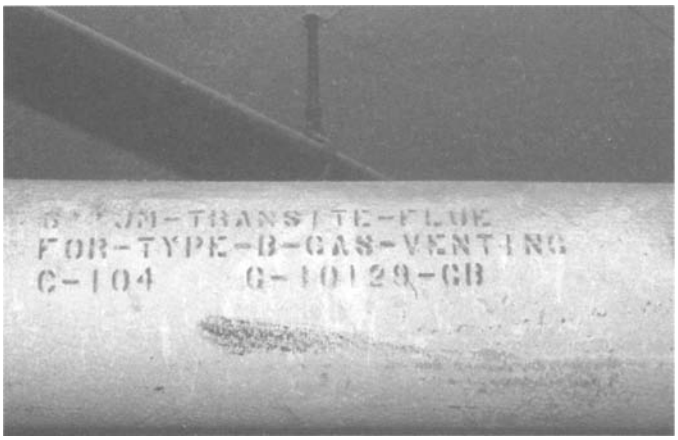

Fig. 159—Exhaust flue made of asbestos-cement Transite™.

Fig. 160—Asbestos-cement roofing, siding and pipe.

Fig. 161—Asbestos-cement pavement in farmyard.

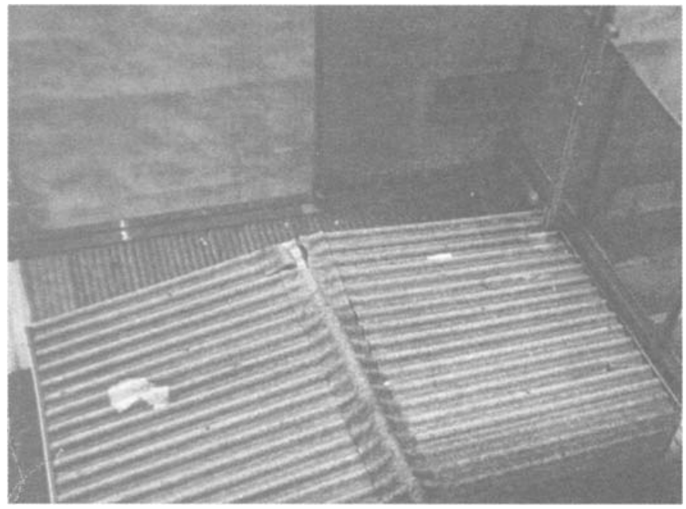

Fig. 162—Old corrugated asbestos-cement roof.

Fig. 163—New corrugated asbestos-cement roof.

Fig. 164—Removing asbestos-cement siding from a factory building.

- Dismantled building components such as the sheets of siding in Fig. 165 should be removed as intact as possible and lowered to the ground, not dropped or thrown.
- Work should be done with hand tools as much as possible. The use of power tools such as the circular saw in Fig. 166 (taken during a test inside a negative pressure enclosure) should be limited to low speed, preferably with a dust-capture attachment.
- Pipes and other voluminous items should not be crushed to reduce disposal volume. They can be filled with bags of debris and other waste and used as disposal containers.
- Dirt contaminated by debris from outdoor removal should be picked up with shovels and put in disposal bags. The surface of the dirt should contain no visible debris.

For another approach to abatement of asbestos-cement building materials, see the part of this chapter titled **"Dismantling Components with Intact ACM."**

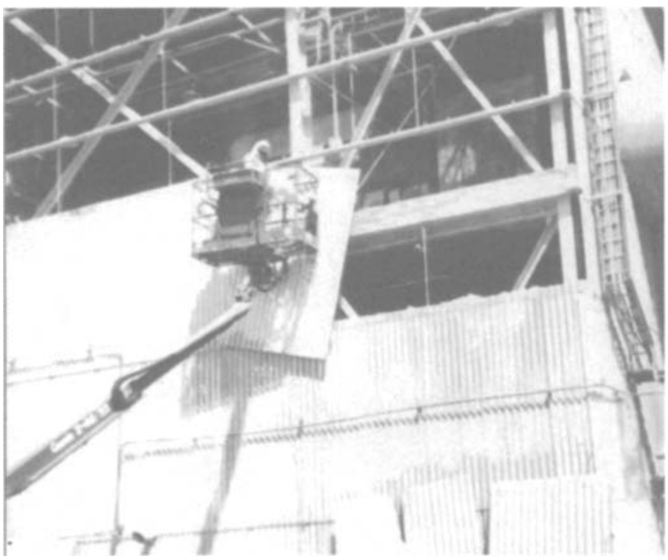

Fig. 165—Removing asbestos-cement siding from an industrial facility.

Fig. 166—Cutting asbestos-cement sheet with a circular saw.

Alternative Abatement Methods

Use of Glove Bags for Abatement

The visual inspection requirements in ASTM E 1368 for using glove bags to remove pipe insulation on an *abatement project* conform to the OSHA regulations in 29CFR1926.1101, including smoke-tube testing of the glove bags. Even though the OSHA regulations permit the use of negative pressure in a glove bag, ASTM E 1368 recognizes that this is infrequently done. Because OSHA rules do not permit a glove bag to be moved for re-use, multiple glove bags are frequently used on long runs of pipe insulation, as shown in Fig. 167 (note the HEPA-filtered vacuum). OSHA rules require that two persons perform a glove bag operation for Class I work—meaning abatement.

The schedule and procedures for activity before, during and at the conclusion of the work are similar to those for gross removal discussed in Chapter 4. The inspection for completeness of preparations should include any plastic sheets that cover floors and equipment under the pipes where insulation will be removed. Because much of this work is done in mechanical rooms, special attention should be paid to protection of equipment that must remain energized and to hot components. One of the unsung advantages of glove bags is their ability to control water as well as airborne fibers, which is a good reason to use them near equipment that is susceptible to water damage or could create a safety hazard. However, glove bags leak and they get dropped, so nearby surfaces and equipment must still be protected.

It is common practice to only remove insulation from the fittings if the straight runs of pipe insulation do not contain asbestos. Figure 168 shows tees, valves, and hangers after removal of the insulation, with the remaining fiberglass insulation on either side sealed with duct tape. There is one drawback to leaving the old fiberglass insulation in place. It is probably thinner than the new insulation being put on the fittings (Fig. 169) and the result may not be aesthetically pleasing.

Fig. 167—Two workers using multiple glovebags on long pipe run.

Fig. 168—Pipe fittings after glove bag removal of insulation.

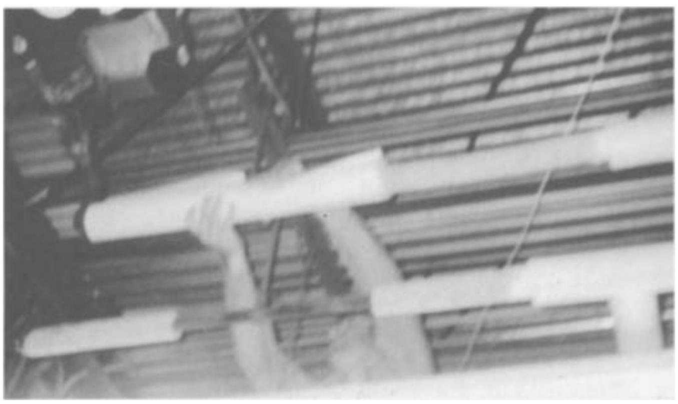

Fig. 169—New and old fiberglass pipe insulation has different thicknesses.

The actual procedures used for attaching the glove bag, removing the insulation, cleaning the abated surface or component, and removing the glove bag follow a basic pattern but differ somewhat in the details. For example, some prefer to put the tools in the pouch, attach the bag to the pipe, then seal the bag. To avoid the workers having to support the weight of the tools while they hang the bag, it is better if they attach the ends of the bag to the pipe and then put the tools in the pouch before sealing the bag. Some bring the tools out through an inverted sleeve, while others put them back in the pouch and cut the pouch off the bag. A project designer with specific preferences for glove bag procedures should identify them in the specification. Another approach is to require the contractor to submit detailed procedures at the Pre-Construction Meeting. Either way, the project monitor must be familiar with the procedures that will be used.

Acceptance criteria for glove bag removal are the same as for gross removal: no visible residue on the abated surfaces or components, and adjacent unremoved material that is to remain in place should be protected with mastic and adhesive cloth. If done properly, glove bag removal usually does not result in the widespread contamination with water and debris that can result from gross removal. Therefore, the visual inspection for completeness of cleanup is usually shorter and simpler, as the project monitor can concentrate on part of the work area where the removal and the handling of bags actually occurred.

Abatement with Mini-Enclosures

There is no clear delineation as to what makes an enclosure "mini-" but some general features distinguish a mini-enclosure from the conventional enclosure and decontamination facility discussed in Chapter 4. A mini-enclosure has no shower and no separate load-out for removed material. It usually consists of two chambers: a work chamber in which the ACM is removed, and a change room, in which the worker(s) remove contaminated clothing. Worker(s) are expected to perform further decontamination remote from the mini-enclosure, perhaps in an actual abatement decontamination facility, or in a restroom or locker room.

The mini-enclosure is usually much smaller than the conventional enclosure and according to OSHA regulations ". . . accommodates no more than two persons. . . ." Whether that means the mini-enclosure can only be large enough for two persons or that no more than two can enter at a time is not clear. A mini-enclosure is often freestanding and remains in place for a relatively short period of time. Often, the work is performed overnight or during one shift. The amount of ACM removed in one mini-enclosure at one time is well below that removed in a conventional containment. More than one mini-enclosure, of course, may be used for an abatement project, particularly if the ACM is widely scattered through the building. A mini-enclosure may be used once, then disassembled and the plastic disposed of as contaminated material, or it may be cleaned, moved, and used again. Mini-enclosures have been constructed on scaffolds and a small equipment room or other space with a change room attached to the door could qualify as a mini-enclosure. Portable, prefabricated units intended for re-use are easily constructed and are also commercially available. For outdoor work at industrial facilities, mini-enclosures are often the only practical approach.

A mini-enclosure is placed under negative pressure, usually by a HEPA-filtered vacuum located outside the enclosure with the hose going through the change room into the work chamber. Figure 170 shows the correct arrangement to avoid drawing contaminated air into the change room. It is

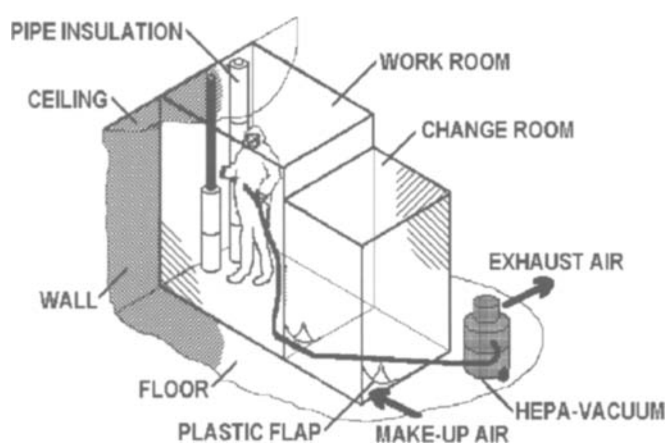

Fig. 170—Schematic representation of correct mini-enclosure layout.

also common to see small HEPA-filtered exhaust units with adjustable airflow used with mini-enclosures (Fig. 171). A mini-enclosure may be placed under negative pressure for gross removal, or to provide additional protection during glove bag removal. Because of the small size of the mini-enclosure, a large number of air changes per hour are produced, even with a HEPA-filtered vacuum.

"Spot removal" is abatement in a very limited area for a specific purpose. It may be performed as preparation for an abatement project to remove enough ACM from a beam, deck, or ceiling to install a critical barrier. Figure 172 shows a variation called "strip removal" where the fireproofing was removed from the bottom of a flange to build a temporary construction wall. Another application is to remove enough ACM from a small area so that unprotected tradesmen can perform work related to renovation. For example, pipes in ceiling plenums may be insulated with asbestos, and the plumber cannot make pipe connections until the some of the insulation is removed. Spot removals are usually performed in buildings that must remain occupied and are usually done at night or other periods of low occupancy.

Some of the things for the project monitor to remember about visual inspection of work done in mini-enclosures:

- Be prepared to respond quickly and work nights, especially with spot removals for renovations. In such cases, the time frame for removal, cleanup, inspections, air sampling, and disassembly is greatly compressed; all of these things might have to be done between the close of business one day and opening the following morning.
- Be prepared to cover widely scattered locations and keep track of multiple setups and teardowns. Make sure the record keeping is arranged in advance to document setups that need to be inspected, and which ones have passed inspection of preparations, completeness of removal and completeness of cleanup, and post-disassembly inspection.
- It may be necessary to work around furniture and equipment that would normally be removed for an abatement project; instead, these items will have to be moved aside, covered with plastic and inspected to verify that they remained clean.
- The project monitor and workers will have to go somewhere to finish decontaminating after leaving the mini-enclosure. The location, which should be identified in the specification, may be a regular decontamination facility if other abatement is in progress, or a restroom, or a locker room of an industrial plant. Building owners get nervous about occupants seeing workers in disposable suits and respirators. After discarding the contaminated suit in the change room, put on coveralls (disposable or otherwise) of a subdued color (not white or yellow) wipe off your respirator, step out of the change room and take off the respirator before walking through the plant or building. Be discreet and do not attract attention to yourself.
- The "temporary" nature of the mini-enclosure is no excuse for sloppy construction and work. To the contrary, there may be a very limited time between disassembly of the unit and re-occupancy of the area, with no second chance to clean up extensive amounts of debris.
- The criteria for acceptance of completeness of removal and cleanup, and the procedures used to determine if the work passes or fails, do not change from those enunciated earlier. The major difference in many applications of mini-enclosures is the pressure to complete all of the tasks within a limited time without compromising the effort.

Fig. 171—Using small HEPA-filtered exhaust unit with mini-enclosure.

Fig. 172—Performing "strip removal" before attaching construction wall to beam.

Dismantling Components with Intact ACM

Dismantling consists of leaving the ACM on the component, removing the entire component from the premises and disposing of it, ACM and all, suitably wrapped and labeled. For example, HVAC ducts can be cut to length and, to reduce disposal volume, flattened before they are wrapped. The mastic on the ducts in Figs. 173 and 174 contained asbestos. Rather than have the abatement contractor remove the strips of mastic and underlying foil and fiberglass insulation, then have another contractor remove the ducts themselves, the owner elected to have the abatement contractor remove the ducts with the mastic in place. The illustrations show the ducts being lowered, flattened and wrapped for disposal.

Large items, such as tanks and small boilers, can technically be disposed of with the insulation intact, but the forces involved in handling them render it unlikely that the insulation will remain in place. Thermal system insulation must be intact and strong enough to resist the forces of handling and transportation. Do not count on 6-mil plastic to

Fig. 173—Duct with asbestos mastic being lowered from plenum.

Fig. 174—Duct flattened and wrapped for disposal.

prevent the ACM from falling off. If the insulation is not in good enough shape to remain intact, remove it instead. Two large insulated autoclaves wrapped in plastic were dragged out of the building with a back-hoe and it was not a pretty sight: by the time they reached the door, the plastic and most of the insulation had fallen off. Large items with nonfriable ACM are more readily and safely disposed of intact. The cooling towers in Fig. 175 were wrapped and taken to a landfill without removing the asbestos cement louvers. The floor tile removal shown in Fig. 152 is a form of dismantling.

The advantage of dismantling is that most (if not all) removal, cleaning, and inspection is eliminated. The disadvantages include:

- The possibility of the ACM coming off unintentionally
- The need to sometimes remove small amounts of ACM in order to dismantle the components
- The greater amount of material going to the landfill as asbestos waste

The project monitor's job is to see that the component is properly wrapped and labeled, that any accidentally dislodged ACM is cleaned up, and to keep track of the number of components removed.

Encapsulation for Abatement Projects

An *encapsulant* is defined in ASTM E 1368 as "a material that surrounds or embeds asbestos fibers in an adhesive matrix to prevent release of fibers." Encapsulation is discussed in ASTM E 1368 as an abatement method in its own right and also to protect unremoved material at the limits of abatement where some ACM must remain in place (Limits of abatement were discussed in Chapters 2 and 4.)

ASTM E 1368 instructs the project monitor to verify that the encapsulant has been applied per the manufacturer's instructions, and then take core samples to measure the depth of penetration (for a penetrating encapsulant) or to measure the thickness of the surface film (for a bridging encapsulant). It specifies the use of ASTM Test Method for Cohesion/Adhesion of Sprayed Fire-Resistive Materials Applied to Structural Members (E 736) and ASTM Practice for Encapsulants for Spray- or Trowel-Applied Friable Asbestos-Containing Building Materials (E 1494). As the titles imply, E 1494 is used on encapsulated materials while E 736 can also be used on materials that have not been encapsulated.

The method in E 736 commonly referred to as the "pull test" for unencapsulated and encapsulated fireproofing is shown schematically in Fig. 176. To test fireproofing on a deck or the underside of a beam flange, a jar lid or similar surface is bonded firmly to the material (Fig. 177). Weights are hung from the attached device or downward force is applied until failure occurs or the test limit is reached. PPE should be worn during these tests (Fig. 178) because a fiber release will result if failure occurs. Separation may occur at the substrate, which is an adhesion failure, or within the material, a failure in cohesion. Figure 179 shows a cohesion failure of unencapsulated high-density fireproofing that occurred at a loading well above the rated bond strength of 200 lb/ft^2 (9.6 kPA) for Monokote MK-6 [11].[1]

E 1494 references E 736 for testing encapsulated fireproofing as shown on the right side of Fig. 176. In this test, adhesion failure could occur between the material and substrate or between encapsulated and unencapsulated material, and cohesion failure could occur within either material. The practical usefulness of the "pull test" is limited to downward-facing horizontal surfaces unless the apparatus was

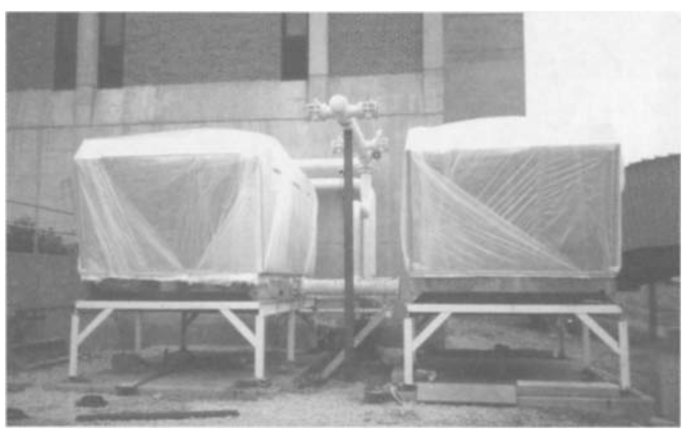

Fig. 175—Cooling towers wrapped in plastic for disposal with ACM intact.

[1] The fireproofing tested was asbestos-containing Monokote in a building in downtown Oklahoma City. The event that allegedly damaged the fireproofing was the explosion on April 19, 1995.

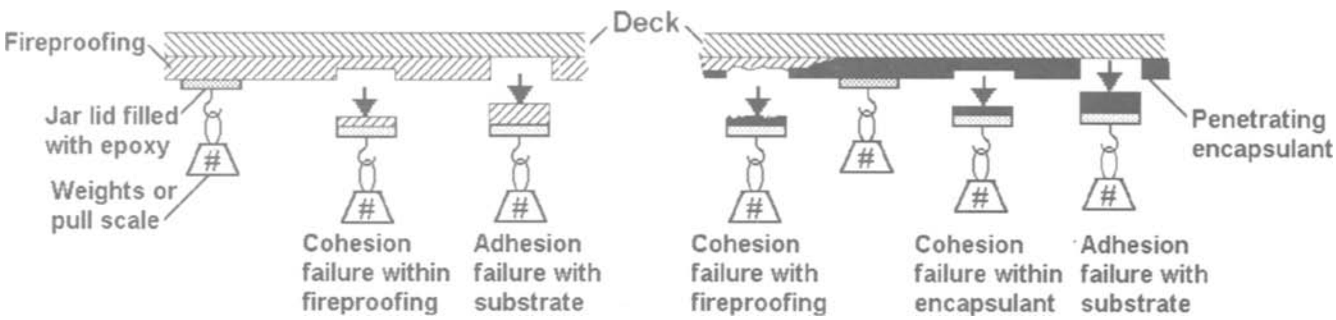

Fig. 176—Schematic of E 736 test for fireproofing performance.

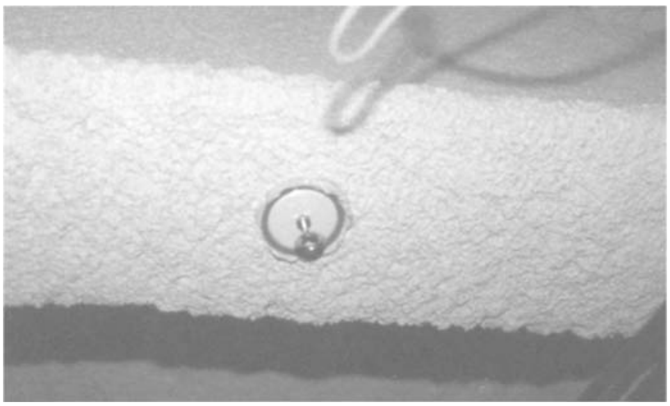

Fig. 177—Jar lid bonded to fireproofing.

Fig. 178—Worker adding weights to increase loading for "pull test."

rigged to exert a horizontal pull on a vertical surface such as a column or the web of a beam.

E1494 defines a penetrating encapsulant as that which penetrates the material to a depth of at least $\frac{3}{8}$ in. (1 cm). Otherwise, it is a bridging encapsulant. To determine the depth of penetration, a plug is removed to the substrate with a coring tool and placed in a beaker of water without agitation. After the plug has soaked and the unencapsulated material loosened, the thickness of the plug is measured.

The project designer must determine if encapsulation is an appropriate response action, considering the condition of the ACM and substrate, the use to which the functional space will later be put, and other relevant factors. The time to find out that the fireproofing is too light and fluffy to support the encapsulant, or that the substrate stays wet from a leaking roof, is early in the project and not during the visual inspection.

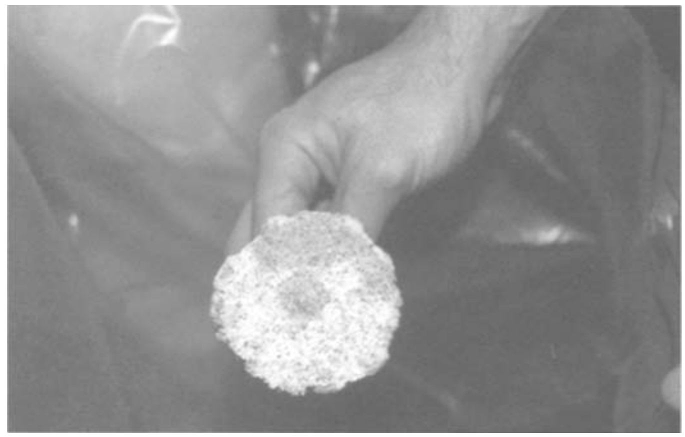

Fig. 179—Cohesion failure of fireproofing.

Chapter 4 stressed the importance of identifying locations where ACM is to remain intentionally in the building. Renovation projects will often involve removal only in a certain part of a building, while surfacing material and pipe insulation crosses walls and floors that separate the removal area from spaces that will not be renovated. It is important to specify what is to be done to prevent the release of fibers from remaining ACM that is accessible inside the enclosure in order to pass the visual inspections and aggressive air sampling for final clearance, and to eliminate a hazard to unprotected occupants after the area is cleared.

Two examples illustrate this problem as often encountered with surfacing materials. Figure 67 in Chapter 4 shows a beam with inaccessible fireproofing behind it and Fig. 180 shows a column in the same building. The accessible fireproofing on the beam and column was removed and penetrating encapsulant sprayed liberally into the cavities to saturate the concealed fireproofing. Figure 181 shows the encapsulant running down the wall from behind the beam as well as the sealer applied to the exposed surfaces.

In Fig. 182 fireproofing remains between the deck and a beam to which the critical barrier is attached, as seen from inside the enclosure. The space on the other side of the barrier was not abated on this project, but it was necessary to protect the exposed material between the beam and deck in order to clear the space being abated. In this case, the exposed ACM on the enclosure side of the critical barrier was covered with an encapsulant.

Fig. 180—Column with inaccessible fireproofing in cavity.

Abatement in Crawl Spaces

Working in crawl spaces means, "getting down and dirty." It doesn't get any less glamorous, being up close and personal with large cockroaches, open sewer lines, remains of animals, and other unpleasant surprises. It is no place for the weak of stomach or the claustrophobic. Crawl spaces are different from occupied areas in the building, not only because they usually have a dirt floor and low headroom, but also because they are entered infrequently for short periods of time by a limited number of persons. Why would anyone need to go into a crawl space? One reason is to install and maintain networks of communications wiring as shown in Fig. 183.

Asbestos abatement in crawl spaces usually consists of removing thermal system insulation from pipes and ducts, picking up pieces of insulation that have fallen or been taken off, and removing contaminated dirt. A thorough Project Design Survey—meaning an inspection of the crawl space—is essential to determining the location and extent of contamination for the preparation of the plans and specifications. It is very important to limit abatement activities to the location of the pipes and ducts, plus areas over which debris has been scattered by previous activities and areas that may be traversed (and possibly contaminated) by abatement workers. If the pipes run along one wall and the insulation has not been knocked off and scattered around, it may not be necessary to remove dirt throughout the entire crawl space. The project designer should determine these conditions, and the contract documents, particularly the drawings, should state the limits of abatement accordingly.

Fig. 181—Beam with encapsulated inaccessible fireproofing.

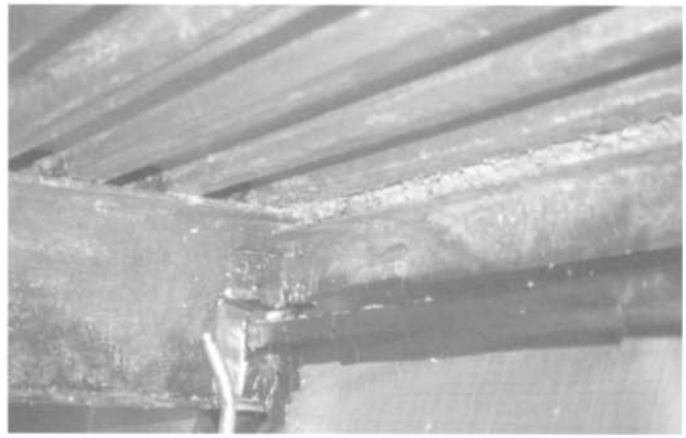

Fig. 182—Fireproofing between deck and beam above critical barrier.

Figure 184 shows asbestos insulation that has fallen off ducts in a crawl space. Pieces are lying on the ground and mixed in with a layer of dirt that may be an inch deep. Underneath there is hardpan, or sub-grade, in which some pieces of ACM may be impacted or buried. Controversy exists over how deep the workers need to dig to remove

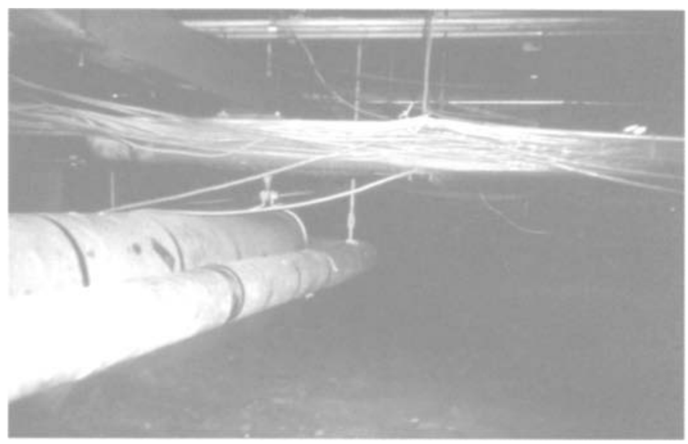

Fig. 183—Communications wiring underneath building.

Fig. 184—Contaminated dirt in crawl space.

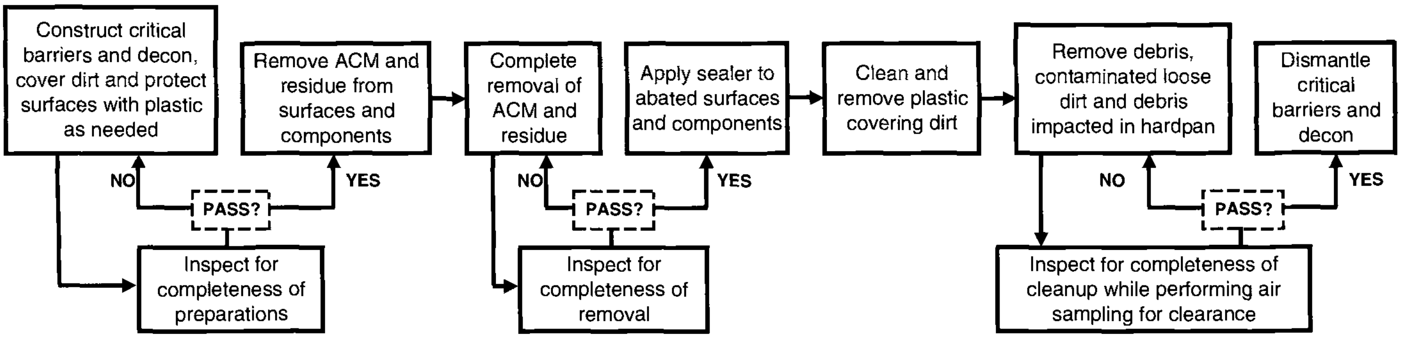

Fig. 185—Sequence of activities and inspections for crawl space abatement.

enough ACM and contaminated dirt. Asbestos materials do not "burrow" into the hardpan—a piece of friable insulation debris, if stepped on, will crumble before it penetrates very far. In most cases, pieces of debris will be limited to the top half-inch or so of the surface. Situations do exist where ACM is buried in filled-in trenches, or is carried by water into fissures or very porous dirt. These conditions should be found during the Project Design Survey and addressed in the plans and specifications, as well as at the Pre-Bid Conference.

When inspecting the preparations for abatement in a crawl space, the peculiar characteristics of the environment must be considered. The walls will generally be brick, concrete, or masonry block, with rough surfaces that are hard to clean if they get contaminated. On the other hand, the contractor is probably not going to be scraping a ceiling or removing fireproofing, and it is easier to control the water when removing pipe or duct insulation. The walls, therefore, only need to be protected within "splash distance" (see Chapter 4) of the pipes and ducts from which insulation is being removed. A layer of 6-mil (0.15 mm) plastic should be placed underneath the pipes to catch falling debris and contaminated water. Glove bags are often used in crawl space abatement, which helps keep the dirt from getting more contaminated than it already is. The "floor" is an uneven dirt surface, and any attempt to keep the plastic from shifting around by taping it down will be futile. Keep in mind that the dirt underneath is already contaminated and will be removed as soon as the pipes and ducts are abated.

OSHA regulations require that the crawl space be under negative pressure as this is Class I work. There must also be a full decontamination facility and load-out for the removed material, including the dirt. If the space is very small, set up a mini-enclosure at the entrance. On one project, the public housing authority did not want the residents to see anyone wearing respirators or protective clothing outside the building, so we suited up in a remote trailer and were taken to the buildings in a van, which let us out at the hatch leading to the crawl space and took us back to the trailer.

Figure 185 shows the sequence of activities and inspections for abatement in a crawl space as required by ASTM E 1368 and Fig. 186 illustrates these activities schematically. The inspection for completeness of removal will concentrate on the pipes and ducts from which ACM has been abated. This inspection proceeds as it would for pipes and ducts in any other location, and the criteria for acceptance are the same: no unremoved material and no visible residue. After the inspection is passed, sealer is applied to the abated surfaces, not to the dirt.

After the sealer is applied and the plastic is removed from underneath the pipes and ducts, dirt cleanup may be conducted by manual methods, using shovels, rakes, and various hand implements, with the dirt placed in bags and drums for disposal. Vacuum-assisted devices are often used in crawl space abatement. Amended water is used with manual cleanup and is encouraged for use with vacuum devices providing the resulting mud doesn't clog the hoses. The vacuum-assisted device has the added advantage of contributing to the negative pressure in the crawl space because of the air it is exhausting, but only helps while the device is operating. Conventional negative air machines are still needed to maintain negative pressure while the vacuum device is turned off for bag changing, maintenance, and other reasons.

Some specifications require that dirt be removed to a certain depth, usually 4 or 6 in. (10 or 15 cm), but there are serious problems with that approach. As stated earlier, ACM isn't found that deep very often, and if it is, the specific locations where it exists should be determined during the Project Design Survey and shown on a drawing. **The emphasis for the contractor should be on removing asbestos, not dirt.** With a depth of removal requirement, contractors can claim to meet their obligation by removing sufficient dirt while leaving visible debris in the remaining dirt. Finally, with the uneven surface in most crawl spaces it is difficult to verify how much dirt has been removed.

To determine if the dirt in a crawl space is clean, get down on your hands and knees with a strong light and look closely. With a small screwdriver or other pointed tool, sift through any remaining loose dirt to look for friable material, and scratch the surface of the hardpan to find any impacted ACM.

The contractor's competent person and at least one worker accompany the project monitor, and if minor amounts of debris are found in the dirt, a worker removes the contaminated dirt without attempting to pick the crumbled debris out of it. Except for obvious non-asbestos trash, mortar, rocks, and concrete, all debris is considered asbestos and the dirt containing it is removed. Minor amounts of ACM impacted into the hardpan should be dug out by the worker(s) assisting during the inspection. If widespread contaminated dirt or impacted debris is found, terminate the inspection and direct the supervisor to have the crawl space re-cleaned. Visual inspection is facilitated if the removal activity is limited to the areas of the crawl space where ACM has been present, and if care is taken during removal not to spread asbestos and contaminated dirt into previously clean areas.

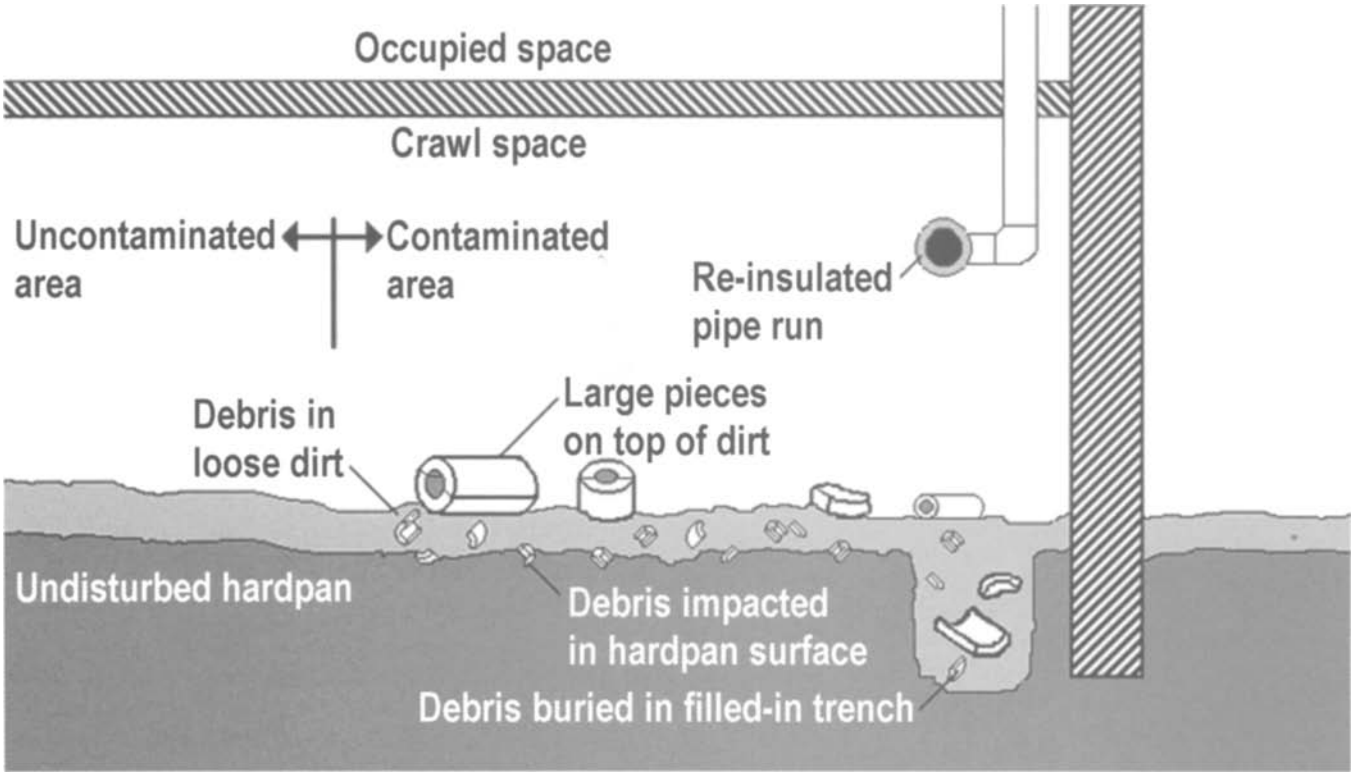

Fig. 186—Schematic illustration of crawl space abatement activities.

The inspection of the dirt floor is properly considered an inspection for completeness of cleanup. The criteria for acceptance as given in ASTM E 1368 are:

- There can be no debris lying on the surface of the dirt.
- All loose dirt contaminated by visible debris must be removed down to the hardpan.
- There can be no visible debris impacted into the hardpan.

To reiterate, **the emphasis in ASTM E 1368 is on the removal of asbestos, not the removal of dirt**. No specific depth of removal is given in the standard, nor is the project designer encouraged to do so in the specification. If the contractor asks, "How much dirt do we have to remove?" the response is "As much as necessary to remove all visible debris."

While the crawl space is being inspected for completeness of cleanup, final air samples are taken for clearance. The logic behind this approach is given in ASTM E 1368:

> "A personal air sampler worn by the project monitor while performing the final inspection simulates typical area activity and provides a representative indication of airborne fiber exposure risk."

This approach combines the inspection of the dirt for completeness of clean up with the aggressive air sampling for final clearance. It provides a realistic simulation of activity after the space is cleared. It is based on the knowledge that the crawl space will be entered only infrequently for short periods of time by a mechanical contractor, service contractors, and maintenance workers, not by the general public or other building occupants. Leaf blowers are not used for the obvious reason that the dust they would produce would overload the filters.

There is no need to clear the crawl space to a level of 0.01 fibers/cc or to use TEM for analysis of the samples. Because O&M work in crawl spaces will be usually be done in a short period of time, clearance sampling should demonstrate compliance with both OSHA Permissible Exposure Limits. This can be done by having the project monitor, supervisor and at least one worker each wear two personal sampling pumps. One pump on each person runs with the same filter for the duration of the inspection and the filter on the other pump is removed after 30 min. This sampling protocol provides at least three samples to compare to the 8-hr Time-Weighted Average Permissible Exposure Limit of 0.1 fibers/cc and three samples to compare to the Excursion Limit of 1.0 fibers/cc. Samples are analyzed by Phase Contrast Microscopy and all must pass or the area is recleaned.

Opinions vary as to the level of clearance, method of sampling, and type of analysis, and there are probably as many ways to clear a crawl space as there are consultants and project monitors. The only published protocol for sampling and analysis of dirt for asbestos content was developed for Superfund sites [12] and would not be practical to use under a building. Proper abatement of a crawl space can only be determined by visual inspection combined with air sampling as described in ASTM E 1368.

The crawl space should pass final air sampling without the application of an encapsulant to the dirt. The application of an encapsulant after the crawl space is cleared provides an additional measure of protection against fiber release, but should not be relied on in lieu of a thorough cleanup of the

dirt. Post-clearance approaches vary from doing nothing to pouring 4 in. (10 cm) of concrete. An uneven surface can be sprayed with Gunite™ as a sealant. The proper approach depends largely on what will happen in the space after abatement is completed. One structure had asbestos fireproofing in very poor condition and a dirt floor, which was contaminated with falling debris. Knowing that the fireproofing, which was not being abated at the same time as the dirt, would continue to deteriorate and release debris, the dirt was covered with concrete as a post-clearance procedure to facilitate future cleanup.

Contaminated Outdoor Sites

Crawl spaces under buildings are far from the only places where dirt contaminated with asbestos is found. Abandoned and active asbestos mines, mills and asbestos-products manufacturing plants, as well as industrial facilities that use or used ACM are found throughout the world [13].

Figure 187 shows workers preparing to wrap insulated pipe for disposal during the clean up of a 40-acre (16 ha) scrapyard at a chemical plant in Kansas. Much of the insulation on pipes as well as plant equipment up to 10 ft (3 m) in diameter had fallen off and was either lying on the ground or had been buried. Remediation involved wetting and bagging the dirt that was visibly contaminated and taking it to an on-site landfill specifically permitted for this project. Intact components were also buried in the landfill after being wrapped. Heat stress was a concern and the workers were allowed to return to a decon remote from the contaminated area where they could clean and remove their respirators, rehydrate themselves and rest during their shift without going through the full decontamination procedure.

Figure 160 showed part of an asbestos-cement products plant in Israel. A 500 ft (150 m) wide strip between the plant and the Mediterranean Sea was contaminated with waste material containing chrysotile, amosite and crocidolite fiber that had inundated the area over a 45-year period, becoming mixed with dirt and beach sand to a depth of over 3 ft (1 m). Figure 188 is typical of the extensive debris on and below the surface. The hole in the template is ten centimeters on a side—the two large objects next to it are asbestos debris. Because construction would disturb the contaminated soil, 297,000 ft^3 (11.000 m^3) of dirt was wetted and taken in trucks to a landfill. Even so, excavation and saltation of the beach

Fig. 187—Workers clean up asbestos in scrapyard.

Fig. 188—Asbestos debris in excavation near beach in Israel.

sand continued to uncover and distribute contaminated dirt over the site [14]. As part of the remediation, the area just outside the plant fence was covered with 8 in. (20 cm) of clean dirt, a plastic liner, and another 8 in. (20 cm) of clean dirt. The plant is no longer in operation.

Remediation of sites such as these generally consists of wetting, collecting and disposing of a lot of dirt, covering it with a layer of clean dirt, or a combination of these methods. To keep the site from becoming disturbed, vegetation is planted and the area fenced to prevent access. The criteria for determining how much of the dirt to remove are not well-established and visual inspection per ASTM E 1368 is as practical an approach as any. This is particularly true in developing countries where facilities for soil and air sampling and analysis are lacking.

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6

Operations and Maintenance—Living with Asbestos

CHAPTERS 4 AND 5 OF THIS *MANUAL* ADDRESSED *abatement* activities, primarily removal, with getting rid of or otherwise controlling the asbestos as the primary objective. Abatement may have been selected as a response action on the basis of an assessment conducted according to ASTM E 2356 for ACM whose ratings fell "above the line" on the Abatement vs. O&M Decision Chart, or for another reason such as renovation or demolition. The alternative to abatement for ACM whose ratings fell "below the line" on the chart is Operations and Maintenance, or O&M.

This chapter discusses O&M, also known as "managing in place," where asbestos is removed as a necessary adjunct to repair or replacement of components, small repairs are made to damaged ACM, or debris from fiber release episodes is cleaned up.

Definitions and Limitations of O&M

There is a logical and fundamental difference between abatement, whose purpose is to get rid of the asbestos or at least render it incapable of releasing fibers, and O&M, where asbestos removal or repair is an incidental but necessary prelude to some other operation, such as replacing a leaking valve or patching a ceiling. The differences between abatement and O&M reflect the amount of ACM involved, the equipment needed, and manpower requirements, and they show up in regulations, training courses, licensing and accreditation requirements, The fact that OSHA abandoned the phrase "small-scale, short duration" notwithstanding, it remains as a succinct description of O&M work and clearly distinguishes it from most abatement projects. The phrase lives on in ASTM E 1368, numerous state regulations, many training manuals and other documents.

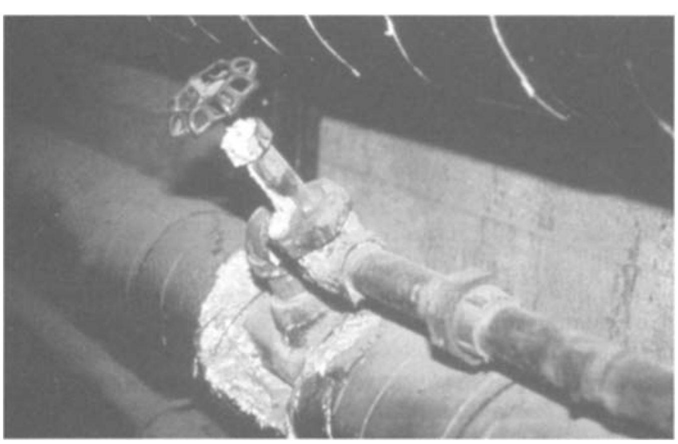

Fig. 189—Removing insulation for pipe tap is O&M.

To see how the visual inspection process in ASTM E 1368 fits into an O&M program, we first need to define O&M and understand its limitations. One definition of O&M is found in the AHERA regulations:

> "A program of work practices to maintain ACBM in good condition, ensure clean up of asbestos fibers previously released, and prevent further release by minimizing and controlling ACBM disturbance or damage."

Take the "B" (for "Building") out of "ACBM" and the above is identical to the definition in the NIBS *O&M Guidance Manual* [1]. The OSHA regulations do not define or use the terms "O&M" or "Operations and Maintenance." ASTM E 1368 defines O&M as part of a response action: ". . . operations and maintenance (such as repair, clean-up, or preventive measures) . . ." An important part of these definitions is not explicitly stated: **The purpose of O&M is not removal for the sake of getting rid of ACM!**

There are some regulatory limitations that apply to O&M work. EPA and OSHA agree on a limit to the permissible quantity of ACM as that which will fit in a single glove bag. The agencies disagree, however, on the size of the glove bag: 60 in. × 60 in. (1.5 m × 1.5 m) according to OSHA (this is found in the definition of *Disturbance*) and 40 in. × 60 in. (1.0 m × 1.5 m) in Appendix B to the AHERA regulations. Except for removing pipe insulation, this limitation cannot be taken too literally, as a lot of O&M work is not and cannot be done in a glove bag. Try to conjure up a mental picture of a glove bag and decide if the ACM involved will fit inside it. If not, the work is an abatement project, not an O&M task. Still, the limitation is open to interpretation. The situation in Fig. 189 where a small amount of insulation was removed to make a pipe tap is clearly O&M. Figure 190 is not so obvious. Taking fireproofing off the beams and deck to replace it with non-asbestos material is clearly abatement, but what about removing enough to find the roof leak? If the water-damaged fireproofing that was removed would fit in a glove bag, even though it wouldn't make sense to use one, is it still O&M?

Some typical O&M activities include:

- Removal of thermal systems insulation with glove bags to repair or replace components;
- Repair or removal of small amounts of damaged thermal systems insulation or surfacing material because of water leaks or other physical damage;
- Cleanup of debris from deterioration or fiber release episodes;

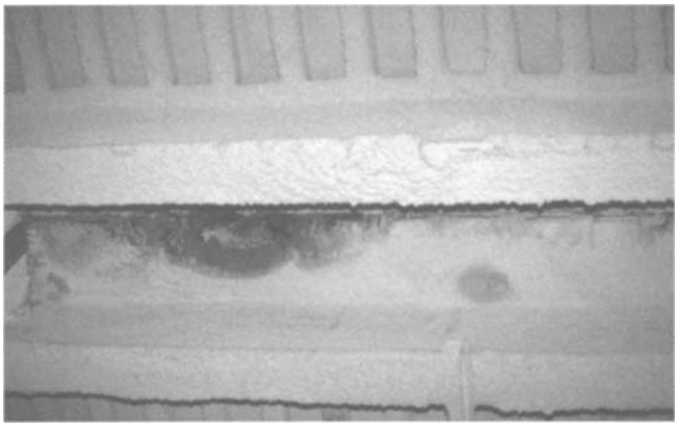

Fig. 190—Removing water-damaged fireproofing—O&M or abatement?

- Preparation of areas to provide an uncontaminated environment for nonasbestos work, sometimes called "spot removal."

For O&M work, a project design is not required unless the work involves cleaning up a major fiber release episode in a school. Nonetheless, the work should be done according to written procedures that clearly spell out the preparation, execution, and cleanup required.

One of the key decisions an Asbestos Program Manager faces is whether to have the work done by an in-house O&M crew or an outside contractor. The trade-offs are discussed in ***Setting Up an O&M Program***. Sidebar 1. Once the decision has been made and implemented, the concepts of visual inspection in ASTM E 1368 can be applied to O&M work as described next.

Visual Inspection for O&M Activities

The differences between applying the concepts of visual inspection in ASTM E 1368 to O&M instead of abatement are those of degree, rather than kind. Everything that can go wrong on an abatement project can go wrong during O&M—it just cannot go wrong on as large a scale. But the building can still be contaminated—if a glove bag is dropped and breaks open, it does not matter if it is one glove bag out of fifty on an abatement project or the only one being used for a pipe repair. The floor still gets wet and fibers still escape. In fact, it may be worse because the room or glove bag may be under negative pressure on an abatement project, while it probably is not for O&M work. The importance of visual inspection during O&M is recognized in ASTM E 1368 because the protective measures of negative pressure enclosures and decontamination facilities are dispensed with to some degree, if not entirely.

Sidebar 1—Setting Up an O&M Program

Contractual and organizational responsibilities are just as important for an O&M program as for an abatement project. The chapters on conducting surveys and abatement projects stressed the need for an individual within the building owner's organization to take charge of these activities, and this also applies to the O&M program. One of the first decisions the Asbestos Program Manager (APM) will make is whether to have O&M work done by in-house staff or by an outside contractor.

O&M Contracts

If an outside contractor is hired to do the work and a consultant or staff member (who could be someone in the owner's engineering department or the plant industrial hygienist) acts as the owner's representative, the relationships and responsibilities will be similar to those for an abatement project. The scope and nature of the work will differ; however, Fig. 191 shows these relationships and the associated responsibilities that typically apply to an O&M contract.

This type of contract works quite effectively on a task order basis. The consultant or staff member may assist with soliciting bids for the contract in a similar manner to an abatement project. The bid package contains a specification that covers general requirements such as respiratory protection and also includes a set of O&M procedures specific to the plant or building. The bidders quote unit prices for time and materials, and the selected contractor is issued task orders as needed. The consultant or staff member monitors and inspects the work, takes final air samples, and then certifies the area for re-occupancy.

In-house O&M Programs

Many companies and government agencies perform O&M work with an in-house maintenance staff. There is a multitude of organizational relationships, but a simple and effective arrangement is shown in Fig. 192. Forgetting for the moment the complexities of large organizations and who signs whose paycheck, consider the Maintenance Department and Industrial Hygienist analogous to the O&M contractor and consultant or staff member in Fig. 191 for all practical purposes. In this case, the APM should exercise the same degree of control as on an abatement project. The maintenance department functions in a capacity analogous to the abatement contractor, and the industrial hygienist conducts the inspections. Regardless of job titles and size of the organization, it is important that the visual inspection be done by someone other than the person who actually performs the O&M work. "For small-scale operations, the visual inspections may be performed by a foreman or supervisor," as ASTM E 1368 states, as long as someone else does the actual work.

The APM is responsible for ensuring that the maintenance workers are properly trained and equipped, accredited or licensed if necessary, and that they have medical examinations and respirator training. The organization itself may have to be licensed to do O&M work, and this may require liability insurance. The APM, consultant or another staff member prepares the O&M procedures, enlisting the assistance of the O&M workers. When a situation arises that requires an O&M task, the APM selects the proper procedure(s) and prepares a work order. Part of his responsibility is an on-going audit of program effectiveness and corrective action.

The maintenance crew inspects the work area and performs the removal and cleanup required. They provide assistance during the visual inspections for completeness of removal and cleanup similar to that for abatement projects (see Chapters 4 and 5). The inspector performs the visual inspections, takes air samples for clearance after the work, and certifies the area for re-occupancy in a manner similar to the project monitor for an abatement project.

An effective O&M program using in-house staff should fit existing organizational procedures and policies as much as possible. Make as few changes to paperwork and practices that people are familiar with as possible. Let the O&M program work within the system, instead of fighting it.

Sidebar 1—Setting Up an O&M Program—*Continued*

The Catch-22 Of O&M

Whether an O&M contractor or an in-house team is the best approach depends on the facility and organization. Some companies do not want their employees touching asbestos, period. They have O&M contractors. Facilities where frequent replacement and repair of insulated components are a way of life, such as refineries, keep their O&M crews busy and proficient. Therein lies the "Catch-22" of O&M. If a building has ACM in good condition and it is disturbed infrequently, the O&M contract may not find any takers because it is not going to be worth very much. In such a building, however, an in-house crew may not do enough work to stay proficient, and will have to re-learn the procedures on the rare occasions they have to use them. Unfortunately, some of those occasions may be perceived as crises and potential threats to health and the environment. Asbestos O&M work by an in-house staff will be done with the same amount of care and attention that they devote to their other work, and they may resent having to do it at all. Attitudes matter: if workers complain about not having the right tools for asbestos O&M work while management accuses them of losing and abusing their equipment, the stage is set for failure of an in-house program.◆

A lot of O&M work is done under tight time constraints—get in, get it done, and get out. This work tends to be done overnight and on weekends when the building is unoccupied, but it often has to be done in or near occupied areas to clean up debris after fiber release episodes or to perform emergency repairs. There is thus the added pressure of contact with, and observation by, building occupants who may be in a curious or anxious frame of mind about the asbestos.

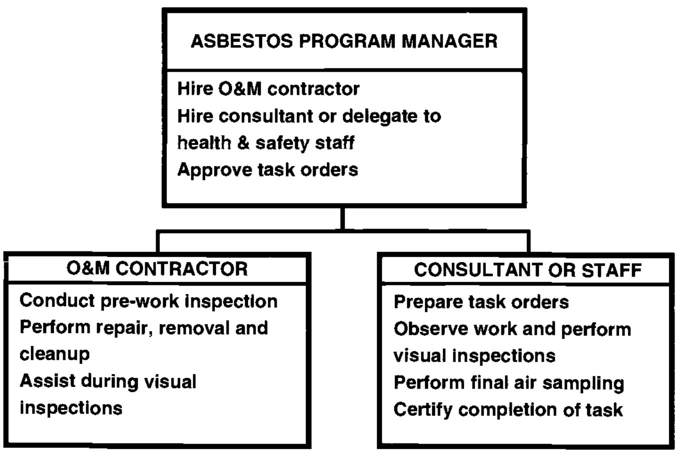

Fig. 191—Roles and responsibilities for an O&M contract.

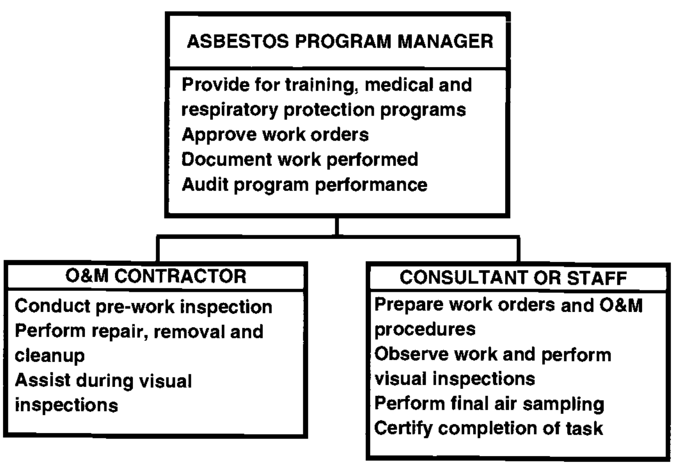

Fig. 192—Roles and responsibilities for an in-house O&M program.

The activities necessary before, during, and at the conclusion of the O&M task to conduct, and successfully pass, the visual inspections are shown in Fig. 193. Note that there are two places to enter the sequence: at "A" for removal or repair of ACM, and at "B" for cleanup following a fiber release episode. For the latter, there is only one inspection: for completeness of cleanup, unless it is also necessary to remove damaged or deteriorated material.

Before the Work Begins

After a task order or work order is issued, the participants review the procedure, assemble the necessary equipment and materials, and prepare the work site. Area preparation is not as extensive as for an abatement project, but items must still be protected from contamination by water and debris. Some procedures and regulations for using glove bags, for example, require "pre-cleaning" the work area and placing a layer of 6-mil (0.15 mm) plastic underneath the glove bag during the work. Use of negative pressure during O&M work is encouraged but often dispensed with. At times, it is simply impractical given the location and nature of the work. As an accommodation to the lack of negative pressure ventilation, wrapping damaged pipe insulation on either side of the glove bag with 6-mil plastic (0.15 mm) is an important preparation step for O&M to prevent fiber release due to shaking the pipe while working inside the bag. In addition to the glove bag preparation steps discussed in Chapter 5, the inspector[1] needs to check this additional item, and others that are indicated in the procedures. Although the requirement in the OSHA regulations to use two workers only applies to Class I (abatement) work, it is strongly recommended that the same be done for O&M (Class III) work.

Cleanup of debris from fiber release episodes may necessitate sealing off an area with barrier tape or otherwise restricting access by unprotected persons, as shown in Fig. 194. The inspector should ensure that this is done before the cleanup starts and monitor the site to make sure no unauthorized person enters.

When entering a ceiling plenum, it is always prudent to lift the first tile very carefully, not knowing what lurks on top (Figs. 195 and 196). Respiratory protection and protective clothing are required where debris is present. To prevent contamination of the room, the use of a mini-enclosure is advised, with a HEPA-vacuum providing negative pressure

[1] The term "project monitor" is rarely applied to O&M work. According to ASTM E 1368, the visual inspections could be done by a foreman or supervisor. Rather than use the cumbersome phrase "the person who does the inspections," we will simply call him the "inspector" in this chapter.

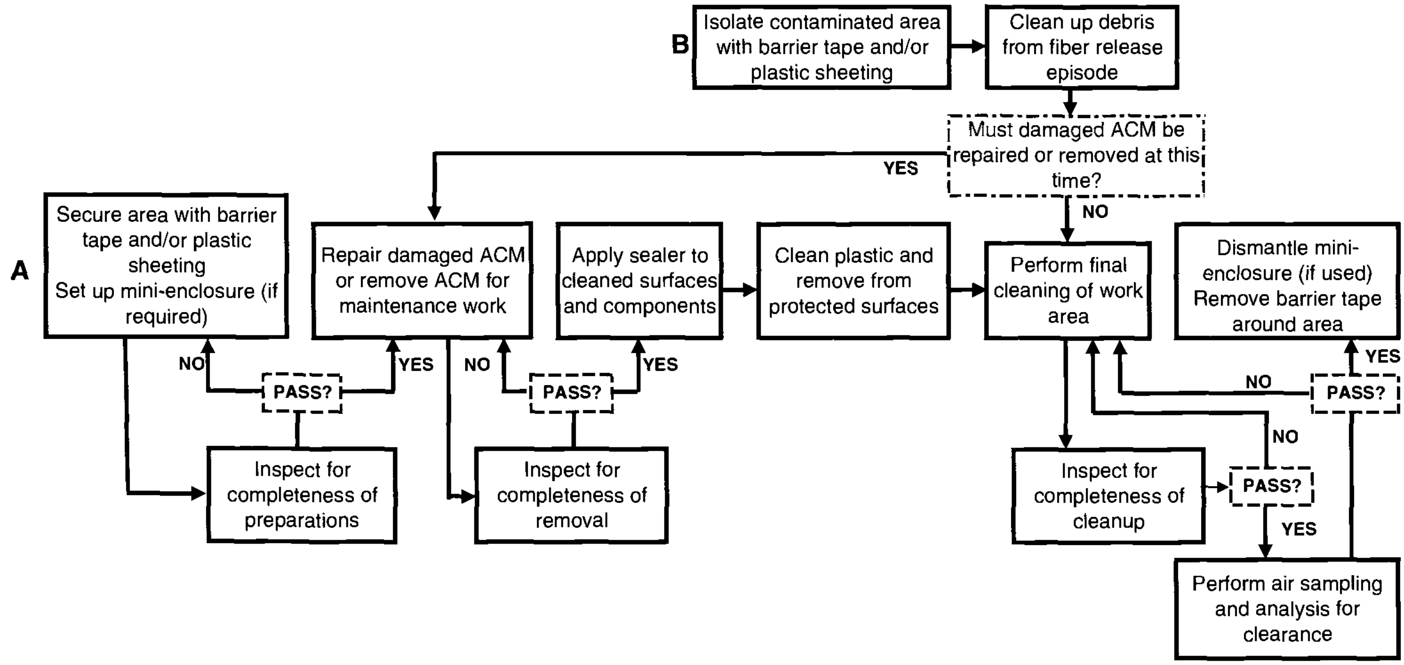

Fig. 193—Visual inspection activities for O&M work.

Fig. 194—Area restricted for cleanup of fiber release episode.

Fig. 195—Pipe insulation on top of ceiling tile.

as shown in Fig. 197. A mini-enclosure that needs to stay up for a short period of time can be attached to the ceiling tiles and floor with double-sided tape. Some facilities where workers enter contaminated ceiling plenums frequently have collapsible mini-enclosures mounted on carts (Fig. 198).

Before commencing work above a ceiling, determine if the plenum is under negative or positive pressure. The use of the ceiling plenum for positive-pressure air supply is rare, but if it occurs, breaching the plenum could result in fibers and debris entering the room. The more common situation of negative pressure in a ceiling plenum for return air introduces the problem of distributing fibers and debris through the HVAC system unless it is turned off (locked and/or tagged out) while the work is being done. Another reason to turn off the HVAC is that a mini-enclosure attached to a ceiling plenum under substantial negative pressure relative to the room may collapse around the person working inside.

During the Work

Unlike abatement, the time between completion of preparations for O&M and the actual removal, repair, or cleanup is very short and often progresses in an uninterrupted sequence. In fact, it may be difficult, and unnecessary, to distinguish between these phases of work for O&M. Therefore, the inspector needs to be present, or immediately available, during preparations to verify their completion without delaying the start of the work itself. The inspector will not have to be concerned with repeated inspections of barrier integrity and site cleanliness that are part of inspecting an abatement project, as the work should be done during one shift or, at most, over a weekend. It is still necessary to monitor the worker's use of water to ensure that debris is not spread beyond the immediate work area, take air samples throughout the task, and check the use of HEPA-filtered vac-

Fig. 196—Fireproofing debris on top of ceiling tile.

Fig. 197—Mini-enclosure with HEPA-filtered vacuum.

Fig. 198—Portable mini-enclosure mounted on cart.

uum cleaners to establish negative pressure in mini-enclosures, small rooms, and glove bags. See ***HEPA-Filtered Vacuum Cleaners for O&M*** **Work.** Sidebar 2 regarding the use of these devices for cleaning up dust and debris.

The material being repaired in Figs. 199 and 200 is an asbestos-containing skim coat over fiberglass insulation on valves in a mechanical room. These figures show the material being wetted and the adhesive cloth being applied. Because this work can be planned in advance and does not involve a fiber release episode, the sequence in Fig. 193 would begin at "A".

It is not always practical to directly observe O&M work while it is being done, and the inspector may impede progress and get in the way by trying to do so. Little is gained by trying to look inside a glove bag while it is being used. There is no room inside a mini-enclosure for an extra body. Unless the worker or supervisor requests the inspector to look at something while the work is in progress, it is better to observe from a short distance. Only if the inspector sees a problem, such as a leaking glove bag or collapsing mini-enclosure, should he intervene.

At the Conclusion of the Work

Here again, the performance of the task segues rapidly into the completion and cleanup phase. The inspector needs to assert himself more strongly during this phase, however, to inspect the work properly and control the pace of the inspection. The inspector must be prepared to respond very quickly, as the workers tend to move rapidly through these activities. The same methods and criteria for determining completeness of removal and cleanup can be applied as were discussed for an abatement project. Somewhat more latitude in final cleaning is allowable here: termination of the inspection and widespread re-cleaning is rarely called for in O&M. The two inspections can sometimes be combined on very small jobs, where the activities in the flow chart tend to run together into a continuum of events.

After the area has been thoroughly cleaned, air samples are taken for final clearance. The only part of the sequence in Fig. 193 that is difficult to compress is the interval between final air sampling and removal of barriers or dismantling of a mini-enclosure, as the final step cannot be taken until the samples are analyzed. Time can be saved by taking air samples during the work with a high-flow-rate pump and letting it run until enough air volume has been collected to establish a minimum detection level below the final clearance limit. The samples (fewer than on an abatement project) may thus be analyzed, using PCM, almost immediately after the task is done. If the fiber levels during and immediately after the work are below the limit, they are not going to increase thereafter. Just in case the samples fail, start another set of samples running as soon as the final cleaning is completed, letting the pumps run while the first set of samples are being analyzed.

The EPA AHERA regulations require a visual inspection as part of determining completeness of any response action in schools. Unfortunately, these regulations do not define visual inspection procedures or criteria in any depth whatsoever. The regulations also exclude small-scale, short-duration projects from final air sampling requirements to determine completion of the response action. ASTM E 1368

Sidebar 2—HEPA-Filtered Vacuum Cleaners for O&M Work

The conventional wisdom suggests that a HEPA-filtered vacuum cleaner should be used to clean up dust and debris from all asbestos work, including O&M. That assertion is open to question on practical grounds and has been refuted by testing conducted to update Negative Exposure Assessments (NEAs). There is also a regulatory basis for dispensing with the use of HEPA-filtered vacuum cleaners when wet methods of cleaning will suffice.

Why would an employer *not* want to use a HEPA-filtered vacuum cleaner? As soon as one is used to pick up dust and debris from ACM or PACM, it becomes a piece of contaminated equipment and must be handled as such. There is a risk of inadvertently opening the unit and contaminating the work area, the hose must be capped and sealed for transport and storage, the bag and filter must be changed inside a mini-enclosure or glove bag by workers wearing PPE, and the waste must be disposed of properly.[1] The alternative is to have such maintenance done by an abatement contractor. Of course the use of a vacuum cleaner without a HEPA-filter, such as a shop vacuum, is not permitted.

Procedures developed for drilling holes through vinyl asbestos floor tile dispensed with the use of HEPA-filtered vacuum cleaners and relied entirely on wet methods for clean up. Tests conducted over a four-year period to update the NEA showed a range of PEL (full test duration) exposures of 0.004 –0.0246 f/cc (averages for each year) and a range of EL (30-min duration) exposures of 0.0142 – 0.0372 f/cc (averages-for each year). These are well below the full-shift PEL of 0.1 f/cc and the 30-min EL of 1.0 f/cc, respectively.

In 1997, OSHA entered into a settlement agreement with the American Iron & Steel Institute that contained the following provision [1]:

> "Pursuant to 29 CFR 1926.1101(g)(1), wet methods, rather than vacuuming, may be used to clean up and collect debris and dust containing ACM or PACM."

This provision does not mention any class of work, so conceivably it could apply to Class I and Class II abatement as well as to Class III O&M work. Although the agreement states that its provisions are limited to members of the AISI, it would be difficult to argue that conditions in the steel industry differ so much from those in other workplaces that the relief granted by this provision should not be available to all employers. This would be especially true for O&M work conducted pursuant to a valid Negative Exposure Assessment.◆

[1] One cannot assume that any HEPA-filtered vacuum cleaner is suitable for use with ACM. One unit had a bag labeled "Clean for health! Shake out frequently."

Reference

[1] Memorandum from John B. Miles, Director of Compliance Programs, Occupational Safety and Health Administration, Washington, DC. to Regional Administrators dated July 10, 1997, and attached Settlement Agreement and Appendix A: Memorandum of Understanding -Application of Construction and General Industry Asbestos Standards to AISI Member Companies.

Fig. 199—Wetting damaged insulation to be repaired.

Fig. 200—Applying wet adhesive cloth to damaged area.

recognizes, without endorsement, that the practice exists of clearing a small-scale response action without the benefit of air sampling. The inspector should be aware that this option is legally permissible, even in schools. Proper visual inspection becomes even more important in these cases, because the absence of air sampling leaves visual inspection as sole verification that contamination has not spread beyond the immediate work site, and that the work area is sufficiently clean for re-occupancy.

Another example of an O&M task is the fiber release episode in Fig. 51 in Chapter 3. The wrapping around the asbestos "mud" on a pipe hanger gave way and the ACM fell onto the (fortunately) empty shelf. The area in which this happened was not occupied. The sequence of activities in Fig. 193 for this situation would begin at "B." The task is to clean up the debris and remove the ACM that remains around the hanger underneath what is left of the covering. A glove-bag removal operation thus accompanies the fiber

release clean up, necessitating visual inspections at the steps in the sequence of activities shown in Fig. 193.

When this work is over it is appropriate to ask a few questions:

- What caused the fiber release—why did the covering fail?
- Was this an isolated incident or, considering the condition of the pipe covering in other locations, is it likely to occur again?
- What are the likelihood and consequences of a similar episode occurring in an occupied area? After the shelves are re-stocked?

The decision to be made is whether to leave the material alone and take a chance on another fiber release episode occurring, repair the pipe hangers and other fittings, or remove the insulation in an abatement project. This example illustrates that an O&M program is a continuing series of choices and problems, and the solutions are not always as simple as some would have you believe. If the contractor or in-house crew is constantly repairing or removing damaged asbestos and cleaning up debris, there probably is a serious lack of awareness about asbestos among the building occupants, a lot of careless and indifferent people, or ACM that is beyond repair for all practical purposes. Maybe it is time to think about an abatement project instead of O&M. A closer look at Chapter 3 on assessment of ACM will help to make such decisions. The next section will make life a little easier when it comes to doing O&M work.

Negative Exposure Assessments

The OSHA Construction Industry standard codifies a new concept in asbestos control—the Negative Exposure Assessment. Don't think too hard about the phrase or take it too literally, but take the time to understand what it means. NEAs, as they are called, can be very useful under the right circumstances.

Two basic requirements of the OSHA regulations are that the employer must assess the exposure of employees who work with asbestos, and that respiratory protection must be provided if exposure cannot be kept below the Permissible Exposure Limits by other means. For O&M work, the 1.0 fiber/cc short-term limit, sometimes called the "excursion limit," is as meaningful as the 0.1 f/cc 8-hr Time-Weighted-Average limit, because most O&M tasks take much less than a full shift to perform. Employee exposure is assessed by personal air monitoring, done according to Appendix A to 29CFR1926.1101, with the samples analyzed by Phase Contrast Microscopy.

An employer can remain in compliance with the OSHA regulations without providing respiratory protection, protective clothing, decontamination facilities and medical surveillance by using an NEA. According to 29CFR1926.1101(f)(2)(iii)(A) one may use:

> "Objective data demonstrating that the product or material containing asbestos minerals or the activity involving such product or material cannot release airborne fibers in concentrations exceeding the TWA and excursion limit under those work conditions having the greatest potential for releasing asbestos."

An employer who uses this approach relies on the manufacturer of the product to conduct the testing that certifies compliance with the PELs. Another approach is given in 29CFR1926.1101(f)(2)(iii)(B) whereby the employer does the testing. This is a more rigorous process and requires that the following conditions be met:

- The work practices and materials for the current job must "closely resemble" those of the Initial Exposure Assessment;
- The workers for the current job must have been trained on the procedure and materials similar to those in the Initial Exposure Assessment;
- Less than twelve months must have elapsed since the Initial Exposure Assessment or the last employee exposure monitoring.

Not all O&M work is eligible for an NEA. In OSHA's words, respirators must be worn during "Class III asbestos work when TSI or surfacing ACM or PACM is being disturbed." An NEA for removing insulation from a leaking valve, even inside a glove bag, wouldn't relieve the employer of the responsibility to provide respiratory protection.

Let's be clear that NEAs *permit* employers to dispense with certain precautions and remain in compliance *if they choose to do so*. Some employers still use some or all of these precautions even if an NEA is in effect because that is their policy.

Notice the reference to an "Initial Exposure Assessment," or "IEA." Until shown otherwise, any work involving ACM is considered capable of producing exposure above the PELs. The IEA is a test of a specific procedure on a specific material during which air samples are taken for comparison to the PELs.

Because exposure is unknown until the IEA is conducted, this first set of tests must be done inside a negative pressure enclosure with the participants wearing respirators and protective clothing. A decontamination facility with a shower is not necessary, just a change room for "double-suiting." (Fig. 201) When leaving the test chamber, the outer disposable coverall that might be contaminated is discarded and the person exits the change room wearing the clean inner garment. An abatement contractor usually supplies the workers to perform the task under assessment and constructs the negative pressure enclosure much as he would for an abatement project. The tests are directed by a consultant or other representative of the owner.

Fig. 201—Test chamber for Initial Exposure Assessment.

Even though most O&M work takes less that a full shift, it is still necessary to demonstrate compliance with the 0.1 f/cc 8-hr Time-Weighted-Average PEL. Hence, the worker wears two sampling pumps and filter cassettes during the testing for an IEA (Fig. 202). The cassette on one pump is changed every 30 min—these are the "short-term" samples for comparison to the 30-min "Excursion Limit" PEL of 1.0 f/cc. The other filter remains on for the duration of the test.

It is not necessary to sample for the full eight hours of a standard work shift, but a substantial part of it must be monitored. One approach is to do a 90-min or 120-min test in the morning and two tests in the afternoon of 90 or 120 min each. This produces three "PEL" samples and from nine to twelve "EL" samples. The reason to take so many samples is the OSHA requirement that there be "a high degree of certainty that employee exposures will not exceed the TWA and excursion limit." The criterion to use is the 95% Upper Confidence Limit, or UCL, which is calculated from the following equation [2]:

$$UCL = AC + (1.645)(RSD)(AC)$$

where AC = average concentration in fiber/cc and RSD = relative standard deviation, or the standard deviation (SD) divided by AC.

If the proper procedures are followed, most of the samples taken for an IEA will be below the detection limit for the Phase Contrast Microscopy method of analyzing the filters. In a sense sampling over-estimates the worker's exposure because the actual exposure is really too low to measure accurately. It is not unusual for the samples to show average exposures an order of magnitude below both PELs. To get as many fibers on the filters as possible, run the pumps at the maximum flow rate of 2.5 L/min allowed by Appendix A to 29CFR1926.1101.

Because the same air is being sampled by both cassettes, the average of the fiber levels from the EL samples would be expected to match the one for the PEL sample taken over the same time period. That doesn't happen, and the fact that the detection limit is used for some of the samples is one reason. The total number of fibers should still match, but that doesn't happen either because fiber counting is notoriously unpredictable, especially at low concentrations.

The test director must maintain a steady pace of work: drill a hole through the floor tile, clean the floor and tools, wait 5 min, drill another hole . . . this can try the patience of an abatement worker who has always been pressed for productivity. He needs to be reminded that the purpose of the test is collecting air samples, not drilling holes as quickly as possible or otherwise maximizing the amount of work done.

Tables 8 and 9 present data from an IEA of three asbestos floor tile procedures and various methods of debris and fiber control [3]. "Intact removal" involved cutting and lifting 3 in. × 3 in. (7.6 cm × 7.6 cm) corners from 9 in. × 9 in. (23 cm × 23 cm) tile and the "encapsulant" was shaving cream. These tests, two of which are shown in Figs. 203 and 204, were done by abatement workers inside a negative

Fig. 202—Worker wears two filter cassettes for Initial Exposure Assessment.

Fig. 203—Abatement worker drilling holes with HEPA-filtered vacuum shroud.

TABLE 8—Long-term (PEL) samples during initial exposure assessment.

Procedure	No. of Tests	No. of Samples	Range, f/cc	Average, f/cc	95% UCL, f/cc
Intact removal with water	3	8	0.0067–0.0292	0.013	0.026
Intact removal with encapsulant	2	6	0.0022–0.0175	0.009	0.019
Intact removal with heat gun	2	6	0.0086–0.0344	0.013	0.029
Hole drilling with water	3	10	0.005–0.028	0.014	0.025
Hole drilling with encapsulant	3	8	0.0053–0.0114	0.008	0.012
Hole drilling with vacuum shroud	1	4	0.0037–0.0146	0.010	0.017
Hole punching with water	3	10	0.0053–0.022	0.012	0.021
Hole punching with encapsulant	3	8	0.0041–0.0131	0.009	0.015

TABLE 9—Short-term (EL) samples during initial exposure assessment.

Procedure	No. of Tests	No. of Samples	Range, f/cc	Average, f/cc	95% UCL, f/cc
Intact removal with water	3	12	0.0218–0.2777	0.051	0.164
Intact removal with encapsulant	2	12	0.0123–0.0531	0.032	0.048
Intact removal with heat gun	2	12	0.0245–0.0327	0.027	0.034
Hole drilling with water	3	10	0.0327–0.0694	0.046	0.070
Hole drilling with encapsulant	3	16	0.0237–0.098	0.033	0.062
Hole drilling with vacuum shroud	1	4	0.0204–0.0245	0.021	0.024
Hole punching with water	3	12	0.0204–0.049	0.028	0.042
Hole punching with encapsulant	3	14	0.0245–0.0327	0.029	0.035

Fig. 204—Abatement worker using punch to remove tile wafer.

pressure enclosure. The data from this IEA showed exposures to be well below both PELs for all procedures tested.

Once the IEA is finished, it is up to the competent person to put the results to use. One of the jobs of the competent person is to decide if an NEA applies to an O&M task. If it does, the competent person certifies that the workers performing the task have been trained on the procedure and that the ACM "closely resembles" that used in the tests. Another duty of the competent person is to ensure that training is provided to the workers. For the type of work to which most NEAs apply, training can be provided in much less than the 16 hr called for in the OSHA standard. It is not in the standard itself, but on June 29, 1995 OSHA published a "correction" stating that the required duration of Class III training should be determined by the competent person and that the training must take at least four hours [4].

The data from the IEA can be relied on for one year, after which a new set of air samples must be taken. Because the IEA showed exposure below the PELs, it is not necessary to conduct the tests for the annual updates in a negative pressure enclosure with personal protective equipment. Simply find an area of the building or facility with the type of ACM to which the procedure applies, isolate it from bystanders and conduct the same tests as for the IEA. This can be done with any worker who has been trained to use the procedure—it isn't necessary to call in an abatement contractor. If the results of the IEA were well below the PELs, it might be possible to cut back on the number of tests and samples taken.

Testing by telecom workers for the annual updates, shown in Figs. 205 and 206, dispensed with the precautions taken during the IEA, as the data continued to show they were not necessary (See Sidebar 2). However, one worker did wear a respirator during an annual update because it was the policy of his employer that he does so. It is significant that fiber levels during these tests were well below the PELs even without the use of HEPA-filtered vacuum cleaners.

Fig. 205—Telecom worker drilling holes during annual update.

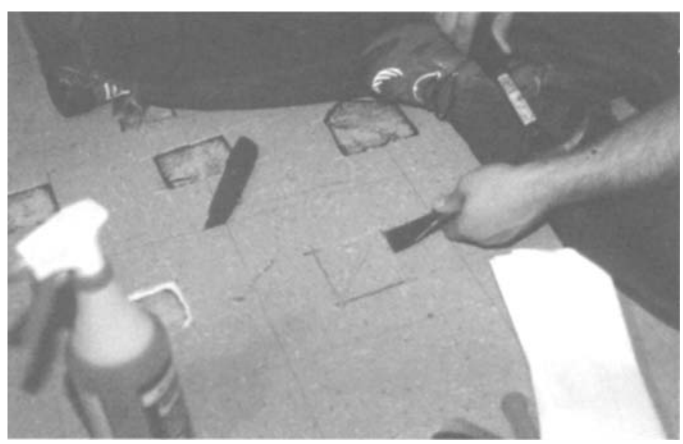

Fig. 206—Telecom worker lifting tile during annual update.

Some final reminders about NEAs:

- Even with a valid NEA in effect, an employer still reserves the right to require the use of respirators and other precautions against exposure;
- They are intended primarily for O&M (Class III) work where non-friable materials are disturbed, or the disturbance of friable materials such as ceiling tiles is minimal;
- An NEA should not be relied on unless the air sampling data show that the 95% UCLs are well below both OSHA PELs.
- The importance of proper training, including hands-on exercises, cannot be over-emphasized.
- Keep records of all the testing and jobs for which NEAs are used because they must be available for inspection by an OSHA compliance officer on request.

O&M for Asbestos-Cement Products

Abatement of asbestos-cement products was discussed in Chapter 5. An entire standard is devoted to O&M work on these materials: ASTM E 2394, Standard Practice for Maintenance, Renovation and Repair of Installed Asbestos Cement Products. Materials covered by this standard include flat and corrugated sheets used for roofing, exterior siding, cooling towers and interior walls, pressure and non-pressure pipes for water and sewage, electrical and ventilation ducts, gutters and many other applications.

The standard includes the rationale for doing the small-scale tasks necessary to maintain, modify or repair these materials if their removal is not feasible. The operations include cutting, drilling, filing, breaking, sanding and other work that releases debris and airborne fibers. An example is cutting the hole in the ventilation duct shown in Fig. 207. Wet methods for dust and fiber control and the use of hand tools instead of power tools are emphasized in E 2394. "Thickened substances" such as the shaving cream in Fig. 208 are described as a means of containing debris and fibers. Reliance on equipment such as HEPA-filtered vacuum cleaners is discouraged because the resources needed to operate and maintain them may not be available in some developing countries where this standard is expected to be used. The intent is to perform the work in a manner that fiber levels are low enough to dispense with the use of respirators, admitting that it may take longer to do so. Users are encouraged to comply with the regulations of their own countries; therefore, no regulations of the United States or other countries are referenced.

The appendices of the initial edition (E 2394 -04) contain step-by-step procedures for four operations:

- Removing Damaged Asbestos Cement Pipe
- Working on Damaged Asbestos-Cement Electrical Ducts Encased in Concrete Slabs
- Drilling Holes in Asbestos-Cement Panels
- Removal of Asbestos-Cement Panels

The standard is structured to allow supervisors, managers, government officials and representatives of non-government organizations to understand the background and rationale for using the procedures in the standard and incorporating them in their own asbestos management efforts. The procedures in the appendices may be taught in training courses for workers or used as checklists in the field by supervisors directing the work.

With the conclusion of this chapter, we have seen how ASTM standards can be used to control asbestos-containing materials. By conducting a Comprehensive Building Asbestos Survey according to ASTM E 2356 (Chapters 2 and 3), we determined which materials to remove and which to manage in place. For those materials to be removed, a Project Design Survey (Chapter 2) provided the information for an abatement project and Chapters 4 and 5 explained how to use ASTM E 1368 to manage it effectively. For those materials that will be left in place and managed through an Operations and Maintenance program, this chapter explained how to use ASTM E 1368 and ASTM E 2394, and also introduced the process known as the Negative Exposure Assessment.

All that remains to be covered in this *Manual* is the important subject of doing all of this work safely, which is discussed in the next chapter.

Fig. 207—Hole cut in asbestos-cement air duct.

Fig. 208—Prying open Transite duct using shaving cream to control debris.

References

[1] *Guidance Manual: Asbestos O&M Work Practices*, National Institute of Building Sciences, Washington, DC. Second Edition, December 1996.

[2] Jordan, R. C., *Reporting the Results of Final Air Sampling: 1. Consideration of Variability. NAC Journal*, National Asbestos Council, Inc. Atlanta, GA. Summer, 1988.

[3] Oberta, A. F. and Fischer, K. E., Negative Exposure Assessments for Special Floor Tile Work Practices, *Advances in Environmental Measurement Methods for Asbestos, ASTM STP 1342*. ASTM International, West Conshohocken, PA. January, 2000.

[4] Occupational Exposure to Asbestos; Occupational Safety and Health Administration, Washington, D.C. Corrections to final rule. Federal Register, June 29, 1995, pp. 33981–33982.

7 Respiratory Protection and Other Precautions

ASTM E 1368 TOUCHES BRIEFLY ON RESPIRATORY protection and safety precautions for the project monitor at an abatement site and ASTM E 2356 also considers them in the context of building surveys. Examples are provided in this chapter of non-asbestos hazards for which pertinent regulations are discussed.

Respiratory Protection

OSHA issued a new Respiratory Protection standard in 1998 under the existing designation of 29CFR1910.134 [1]. At the same time, they deleted Appendix C of both asbestos standards and in its place referenced the new 29CFR1910.134, which applies to all substance-specific standards. 29CFR1910.134 contains new fit test protocols and now requires fit testing annually instead of every six months. Some terminology was changed—the positive/negative pressure fit check performed whenever a respirator is put on is now the "user seal check." It is advisable to do the positive pressure check first, then the negative pressure check. The positive pressure check tends to break the face seal, and since the respirator operates in the negative pressure mode the final check should make sure it works under that condition.

Respirator certification is now a NIOSH responsibility under 40 CFR Part 84 [2] and the most significant change in these regulations for asbestos work is the designation of filter cartridges. The new equivalent of the Type H HEPA-filtered cartridge for protection against asbestos fibers is the P100 cartridge, which meets the same standard for retention of particles.

At an abatement site, the project monitor must follow the same respiratory protection requirements in the regulations and specification that the abatement workers do. For building surveys, an interpretation by OSHA is significant:

> "Bulk sampling for asbestos is a Class III operation as defined by the asbestos standard in construction, 29 CFR 1926.1101. It is a disturbance that entails activities that disrupt the matrix of asbestos-containing material (ACM), or presumed asbestos containing material (PACM). The employee performing the task of collecting bulk samples shall conduct the work in accordance with the work practices and engineering controls as required in paragraphs (g)(9)(i)-(v) of the standard. In summary, these paragraphs require the use of wet methods, local exhaust ventilation where feasible, dropcloths or barriers, and the use of a respirator. Once a negative exposure assessment has been determined, the use of barriers and respirators can be discontinued" [3].

Because the respiratory protection section of 29CFR1926.1101 requires respirators to be used whenever surfacing material or thermal system insulation is disturbed, an NEA for bulk sampling would mostly apply to non-friable materials. Get into the habit of putting a respirator on whenever taking a bulk sample, even for non-friable materials.

The above OSHA interpretation concludes:

> "Professional asbestos inspectors, consultants, industrial hygienist and assistants observed taking precautions, serve as a good role model as well as protecting their own health."

The project monitor at an abatement site and an inspector conducting a building survey would do well to heed this advice.

Safety Precautions for Surveys and Abatement Projects

At an abatement site, the project monitor faces the same hazards as abatement workers do. One should never forget that asbestos abatement is construction work.. According to an OSHA website 1,048 construction workers died on the job in 1995 with 32%, or 335 of the fatalities resulting from falls. Next on the list of fatalities recorded at construction sites was electrocution at 17%. Fire and other emergencies requiring egress also merit discussion, as do hazards from improper use of chemicals. Unfamiliarity with the job site is often cited as a major cause of accidents and this is true whether you are doing a building survey or monitoring an abatement project.

Elevated Working Surfaces

Elevated working surfaces include not only ladders and scaffolds, but all surfaces from which you could fall and be injured. Falls can occur from surfaces intended for access such as catwalks in a boiler plant and surfaces not so intended such as air ducts and ceilings. An unfortunate example:

> "A technician died after apparently falling while inspecting an area above a ceiling at a D.C. elementary school. Seaton is one of 153 D.C. schools being surveyed in an effort to develop asbestos management plans" [4].

The hazards of elevated working surfaces are not limited to abatement sites. Whether inspecting a building or monitoring an abatement project, always be aware of your surroundings when working at heights, as it is very easy to concentrate on the task and not on the hazardous location. Your attention is focused up, toward the ceiling or pipes, and

you tend to forget what your feet are doing. It may slow down the work, but if you cannot see or reach something without leaning over the rails of the scaffold or to the side of the ladder, get down and move it.

One of OSHA's most significant regulatory actions of the 1990s was the Fall Protection Standard for the construction industry [5]. The most visible result of this standard is the use of full-body harnesses for work at elevated locations. Figures 209 shows workers using these devices on a powered man-lift while constructing a large negative pressure enclosure. Although the harnesses are not required to be used if guardrails are provided, the worker in Fig. 210 is stretching the regulation as well as his body to reach and clean a pipe during a visual inspection.

Figure 211 shows fork lifts parked at a battery-charging station in a warehouse with fireproofing on the beam overhead. Taking samples of the fireproofing in this warehouse required donning a full-body harness, tying off to an inertia-reel restraint on the roll bar of the forklift and riding the platform up to the beams. The location shown in the picture was not selected for sampling, out of consideration for the energy that the batteries and charging equipment were capable of unleashing.

Electrical Circuits

Potential danger from electrical circuits begins when you inspect a building for asbestos and enter areas with exposed

Fig. 209—Abatement workers wearing fall protection harnesses.

Fig. 210—Worker leaning across guardrail on powered man-lift.

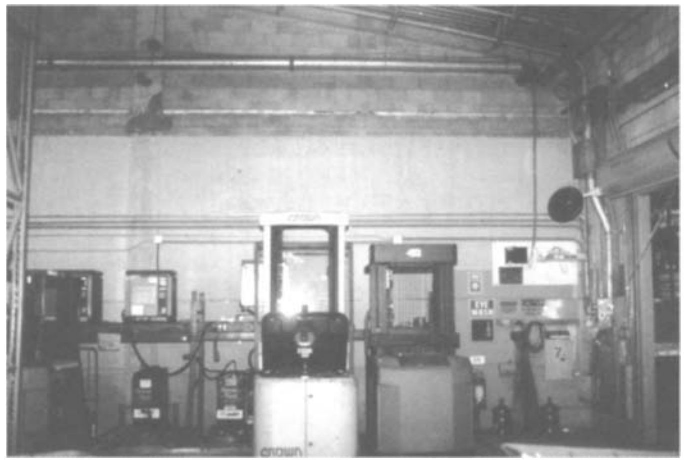

Fig. 211—Fork lift battery charging station.

or damaged wiring and components, and whenever you plug in an extension cord, sampling pump or drop light. Electrical hazards are always compounded by the presence of water, necessitating proper grounding of equipment. That round pin on the three-prong plug is there for a reason: it completes the ground circuit.

Electrical safety on an abatement site begins with disconnecting power to all circuits inside the enclosure—including wall outlets, light fixtures, and HVAC systems—at a panel outside the enclosure. This is preferably done by a licensed electrician who tags the circuits in the "off" position. While in the panel the electrician can bring power out for the contractor's equipment, wired to a panel of circuit breakers provided by the contractor as shown in Fig. 212. Do not forget that circuits may run through the enclosure to other spaces, and these should also be de-energized.

The contractor must bring power into the enclosure with extension cords, which often run through the decontamination facility and therefore run the risk of getting wet if not carefully suspended off the floor. To my knowledge no one has ever been electrocuted in the shower while standing ankle-deep in water in a metal pan being drained by an electric sump pump. If there is any place that a Ground Fault Circuit Interrupter device is absolutely needed, this is it.

Fig. 212—Contractor's electrical circuit board being wired into building power panel.

Fire and Emergency Egress

In case you are wondering why fire and emergency egress are discussed together here, try to name a better reason than fire for leaving a building in a hurry. Several years ago, one man died and five others were seriously burned when solvent being used to remove floor tile adhesive ignited. The solvent had a flash point of approximately 100°F (38°C) and was ignited by a spark from electrical equipment inside the enclosure [6].

It does not take the ignition of a flammable solvent to start a fire. There are a lot of combustible materials in the enclosure and mobilization area. Even fire-*retardant* plastic will burn, and it gives off toxic and combustible gases. The fire consumes oxygen, which a HEPA-filtered respirator does not supply, and asphyxiation can result if you do not get out soon. The fire is also generating carbon monoxide (CO), which causes chemical asphyxiation when inhaled, and your respirator does not remove CO. Even if on Type C supplied-air, leave in a hurry—the heat of the fire causes building materials and furnishings to release gases that are very combustible. When they ignite, it is called a "flashover," which creates the spectacular fireball that blows out the windows. You want to be gone long before that happens.

The project monitor should verify that a sufficient number of fire extinguishers are deployed in the enclosure and decon. Battery-powered smoke detectors are cheap and should be liberally placed throughout the enclosure (Fig. 213). Figure 97 of Chapter 4 shows the exit markings on the plastic flap leading to the decon.

Chemical Hazards

Hazard communication violations are the cause of the greatest percentage of citations issued by OSHA. The standards that apply to chemical hazards in abatement and O&M work are 29 CFR 1926.59 for the construction industry and 29 CFR 1910.1200 for general industry. Training and labeling are the major requirements of these standards and the emphasis is on chemical substances used in the workplace. The solvent that caused the fatal fire discussed earlier is a good example of a case where workers either weren't trained on its use or didn't follow the proper precautions. The labeling requirements for containers in which chemicals are placed are clear and strict. Unless it is going to remain under the personal control of the worker who fills it, the container must be clearly labeled with the identity of the substance it contains. The container in Fig. 214 contains mastic remover, a clear violation of the hazard communication standard.

Use of spray adhesives requires precautions because of their flammability and potential toxicity when inhaled, particularly when working in enclosed spaces.

Brief Exercise On Safety

We are going to conclude this chapter with a brief exercise from the *ASTM Standards for Asbestos Control* course that will illustrate some of the hazards just discussed and ways of dealing with them. The situation is a steam pit, which is sort of an underground mechanical room often located next to buildings on military bases (Fig. 215). The steam pit receives high-pressure steam from a central plant through an underground tunnel and supplies medium-pressure steam and hot water to the building. In this fictitious but realistic example (Fig. 216) the abatement project involves removing the asbestos-insulated tank and associated piping from a concrete pit 8 ft deep, 16 ft long and 10 ft wide (2.4 m × 4.8 m × 3.0 m).

- Chrysotile and amosite insulation on the hot water tank is damaged and the tank is rusted.

Fig. 214—Mastic remover in mislabeled container.

Fig. 213—Worker placing smoke detector on column.

Fig. 215—Steam escaping from pit.

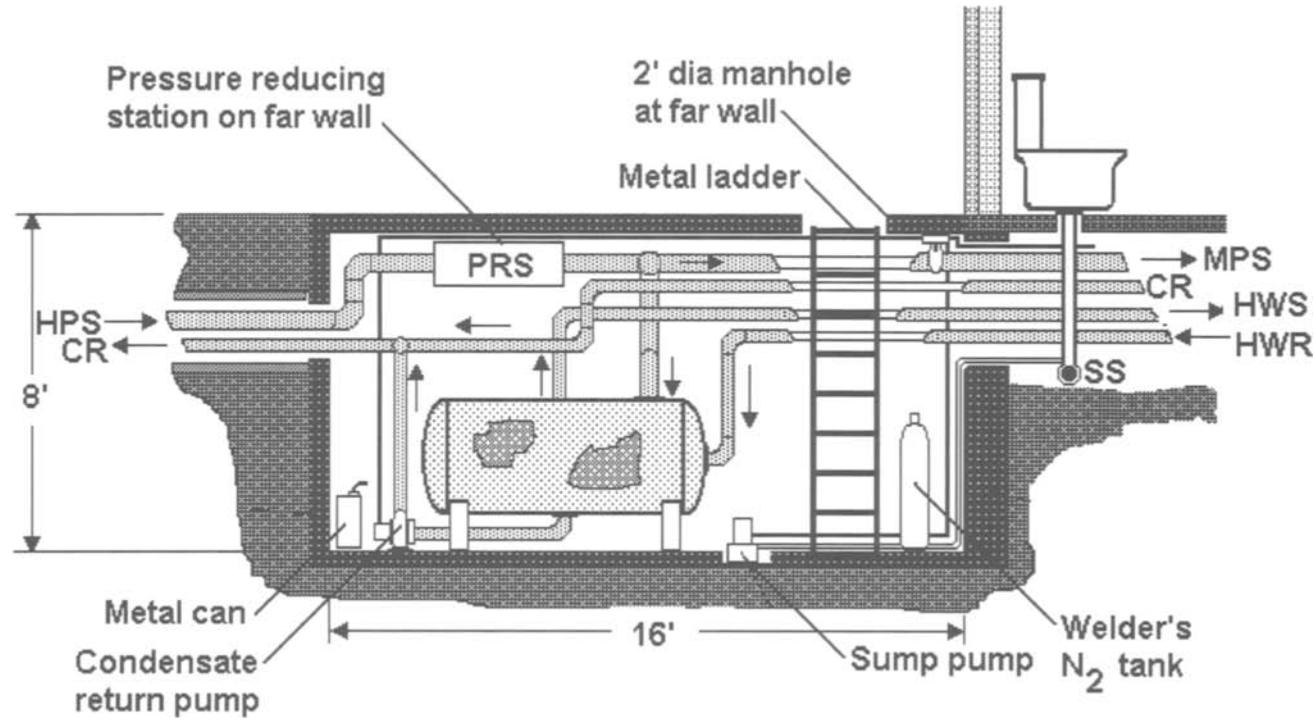

Fig. 216—Schematic of steam pit problem.

- Chrysotile and amosite insulation on pipes and valves is damaged and has fallen off in places (including behind the ladder) and some valves leak.
- The condensate return pump and sanitary drain both leak—there is water on the floor of the steam pit and crawl space.
- The metal can next to the condensate return pump is marked "solvent."
- The adjacent mess hall operates from 5 am to 8 pm and serves three meals daily, seven days a week and steam and hot water must be available during mess hall operating hours.
- The abatement project is scheduled to be done in July.

After pondering this scenario for a while you will recognize the following hazards;

- Asphyxiation from oxygen displacement if the nitrogen tank leaks;
- Explosion hazards and toxic vapors from the solvent can and hydrogen sulfide from the sanitary drain.
- Heat stress and also burn injury from the hot ladder next to the bare pipes.

The pit would have to be treated as a confined space if entered through the manhole, a situation that could be avoided by demolishing the slab and working in the open pit. Some creative solutions were put forth during the classes but filling the pit with concrete was not considered an option.

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Subject Index

ABOUT THE AUTHOR

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Andy Oberta is an asbestos guru and a former rocket scientist who holds the unique combination of Aeronautical Engineering and Master of Public Health degrees. His career segued from designing rocket propulsion systems to contamination control for interplanetary spacecraft to air pollution to asbestos control, in which he has specialized for nearly 25 years.

He is certified in Comprehensive Practice by the American Board of Industrial Hygiene and is licensed as an asbestos consultant in Texas. He is internationally recognized for his work in the asbestos control field, having consulted and lectured in Germany, Greece, Brazil, Israel, Japan and Canada as well as in the United States. His clients include major commercial and industrial firms as well as government agencies. This Manual draws extensively on his experiences, including many projects and research activities that he has performed and managed, as well as litigation support related to the management of asbestos-containing materials. Consequently, it offers not only technical advice on using ASTM asbestos standards, but also the wit and wisdom that his experiences bring to the subject.

Soon after entering the asbestos control field, Andy joined the National Asbestos Council as a charter member, holding numerous offices and eventually serving as president of the Environmental Information Association, as the organization later became known. He joined ASTM in 1986 as Chairman of Task Group E06.24.03 on Asbestos Management, a position he continues to hold. Under his leadership, this Task Group developed three of the standards that are discussed in this Manual. The development of E 2394 Standard Practice for Maintenance, Renovation and Repair of Installed Asbestos Cement Products illustrates his commitment to protecting people in countries throughout the world from the effects of asbestos fibers.

He has served on advisory groups including the Global Environment & Technology Foundation panel that developed the Asbestos Strategies document to guide EPA in formulating asbestos policies and an EPA expert panel on sampling and analysis of vermiculite attic insulation. He has provided technical support to the Federal government on the development of a computerized asbestos management program based on the Customized Compliance Program for Asbestos, a commercial product of Environment-i-média, Inc. (www.environment-i-media.com).

Andy has always considered sharing knowledge with others to be one of his professional responsibilities, and for many years he has conducted asbestos training courses nationwide. As part of this commitment, he served as the lead instructor for the ASTM Standards for Asbestos Control courses for several years. He has made his insights available to a wider audience through the training and information technology products that he produces and distributes through Environment-i-media, Inc.

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Front Cover Image: Scanning electron micrograph (SEM) of asbestos fibers. Image width: 25.7 micrometers.